Edutainment-Multimedia educational content development for school children

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by

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CERTIFICATE

This is to certify that the work contained in this thesis entitled **"Edutainment - Multimedia educational content development for school children"**, by **K.S.Rajamanohar** has been carried out under my supervision and this work has not been submitted elsewhere for a degree.

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ABSTRACT

Edutainment is a recently coined term, a portmanteau that expresses the union between education and entertainment .The field of edutainment has witnessed tremendous growth in research and development of interactive multimedia learning environments in recent years, especially computer-based environments. Researchers and developers are struggling to find innovative ways to exploit the interactive potential of the learning environments afforded by computers while remaining consistent with psychological and philosophical beliefs about how people learn and the practicalities of learning in schools and the work place.

An essentialist view of education maintains that there are things that everyone should know and the best way to achieve this learning is through careful curriculum planning that is rigidly enforced. In this transmission model of education the "all knowing" teacher is expected to deliver or transmit the knowledge society believes its citizens need to know. However, many now feel this demeans teachers by technicizing their role in the classroom. A view holds that any attempt for one group of people to make decisions (e.g. teachers) on what another group of people should learn (e.g. students) is at best misleading and at worst unethical. Educationally speaking, there are little or no rules here. Given the serious work and thought evident in these areas, it is somewhat surprising that one of the most fundamental and important concepts of human interaction has received so little attention by our field - play. Perhaps it is because the word "play" can invoke so many misconceptions.

Research from education, psychology, and anthropology suggests that play is a powerful mediator for learning throughout a person's life. The time has come to couple the ever-increasing processing capabilities of computers with the advantages of play. Microworlds, simulations, and games are the attributes of three well known learning environments (or strategies) consistent with play. A careful blending of their attributes offers promise in guiding the design of interactive learning environments where structure and motivation are optimized without subverting personal discovery, exploration, and ownership of knowledge. In other words, learning environments that encourage people to play.

CONTENTS

Chapter 1

INTRODUCTION

"Immediately to the west of the Great bath at Mohenjo-daro is a group of 27 blocks of brickwork crisscrossed by narrow lanes. Overall it measures 50m East-West and 27m North –South"

- Excerpts from "Ancient India" Textbook for class XII by NCERT.

Reading this in my XII class would not have made any sense to me. As I become an Architect, I could understand that what does it mean. Even it is little tough to visualize as an architect. This must be an excerpt from an Archeological research paper. Organizing literature and some relevant pictures doesn't make the experience of complete learning. Often I feel books are less interactive for elementary and high school children.

Consider these common learner requests.

A. "Can you explain that differently? I don't get it." "I'm stuck!" "It's too complicated!"

B. "I'm bored."

C. "I don't understand. Can I touch? Let me see and hear too."

That is:

A. The diagrams, charts, video, film, animation, theater/plays, pictures, sounds and other changes of perceptual view that teachers and other creative composers frequently employ to help the "stuck" are multimedia. Multimedia provides fresh perspective and metaphor.

B. Learners also need items of high interest. Instructional and other leaders need attention grabbers. Multimedia provides instructional variation.

C. Further, much of what we have learned does not translate simply and clearly to text. In many cases, ideas cannot be adequately understood let alone perceived unless a medium

other than text is employed, whether sounds from a rain forest or photographs from the Hubble Space Telescope of the Orion nebulae. The issue of perception takes on special meaning for those teaching *special needs students*, those with particular handicaps and disabilities. For these students, multimedia may not just provide an alternative perspective. A certain form of multimedia may provide the only point of access for understanding, the only bridge to both "sight" and "insight" for the learner. Multimedia provides awareness.

From this perspective, good educators have always been multimedia educators.
Seven of the major multimedia forms

1 text and programming,
2 still images,
3 audio,
4 video,
5 animation,
6 virtual reality
7 electronics device controllers

Through multimedia technologies, educators can also develop work tailored not to the commercial needs of Cinema, but to the specific educational needs of the students in their classroom. Computer technology provides a "curb-cut" that simplifies and accelerates the development of localized multimedia-based curriculum. That is, multimedia provides ever-greater cultural relevance and educational focus.

There are two major approaches to using multimedia in schools. First, students can learn "from" multimedia, and second, they can learn "with" multimedia. Learning "from" multimedia is often referred to in terms such as instructional television, computer-based instruction, or integrated learning systems. Learning "with" multimedia is referred to in terms such as cognitive tools and constructivist learning environments. One design artifact consistent with multimedia is the constructivist idea of a microworld. A microworld is a small, but complete, version of some domain of interest. People do not merely study a domain in a microworld, they "live" the domain, similar to the idea that the best way to learn Spanish is to go and live in Spain. Microworlds can be naturally

found in the world or artificially constructed (or induced). An educational content can be converted into an artificial environment where the learner will live through.

This thesis aims at creating a microworld based on one of the Indian historical content.3D digital characters and sets can now be built and then presented in different media formats such as film, video and interactive games serving as a source of entertaining education .

Chapter 2

BACKGROUND RESEARCH –1

2.1 EDUTAINMENT

Edutainment is a recently coined term, a portmanteau that expresses the union between education and entertainment in a television program, game or website

Remember the childhood trill of field trips? Instead of spending the day glued to your chair, trying real hard to stay awake and not fidget, your whole class was led like a row of ducklings onto a bright yellow bus that took you to go camping or to a farm or historical site. You got to look and touch and hear about something you didn't already know, maybe pretend you were an artist or a pioneer or an astronaut. You didn't fall asleep, and you didn't once fidget. In fact, you felt excited about learning. It was even, well, sort a fun. That, in a nutshell, is edutainment. The word edutainment comes from the computer industry. It was first coined several years ago to describe CD-ROM programs, mainly for children that were designed for education or teaching and that had an entertainment component to increase their appeal. The term was adopted by the family entertainment industry about a year ago.

Although the term is new, the concept of edutainment is not. Places like zoos, aquariums, botanical gardens, science and children's museums, and tourist and eco-tourist attractions -- location-based entertainment facilities have long used the educational aspects as the draw, while adding entertainment or amusement.

In the age of cyberspace in the twenty-first century, composition, calculation and communication on paper alone is an impoverished, fractional and increasingly outdated concept and practice for thinking and communication. To build on the accomplishments of paper technology, a digital infrastructure must be in place. Schools are in danger of becoming and some have become digital ghettos in comparison with the digital scene of current employment practices. At the same time, the businesses, which are growing the

economy, are not just seeking employees with this knowledge, they are increasingly moving their operations out of areas of low concentration and moving to areas with high concentrations of digitally knowledgeable thinkers and communicators

2.1.1 Changing Culture of Childhood

While biological imperatives remain the same, changes in the physical and social environment in which children live has altered the culture of childhood. Factors like working parents, a concern for safety based on perceptions and reality, and a stronger emphasis on education, has resulted in children's lives becoming more controlled, structured, and physically restricted.

Today's children spend much less time away from the direct supervision of adults. Many no longer even have the freedom to play in their own yards or to have free run of their neighborhoods. Perhaps saddest of all, parenting is often by convenience rather than by commitment, with overworked or disengaged parents seeking canned, pre-packaged opportunities to meet their child-rearing responsibilities.

The lack of opportunity for free-form interaction with nature and other kids, for natural experiences, and for unsupervised open-ended play invisible to adults, has become a serious concern for child development specialists.

How to make the boring education more attractive?

- Make it looks like game
- Add some graphics, sounds, and animations
- Create more interactive contents
- But the most important issue is well organization of the contents
- How can we digest the information into knowledge?

2.1.2 Edutainment Applications

- CAI (Computer Aids Instruction)

- Internet based learning
- Games
- Mobile contents
- Movies and Animations

2.1.3 Contents Developing

- This is one of the most important parts in the Edutainment systems.
- Need experts in the specific knowledge and also specialists of in education field.
- Convert the information into easily understandable form and attractive knowledge

2.1.4 E-Edutainment

- Edutainment is one of the popular contents on the internet.
- As shown in the applications list, there are many applications that can be applied to the electronic business such as Internet Game, CAI web page, or Mobile contents.
- Knowledge + Entertainment + Digital Tech. + Communication Tech.

2.1.5 Importance of Media and Technology in Education

The basic questions asked by the parents when a technology is being introduced are as follows:

- What are the effects of media on the cognitive and moral development of children?
- Is the technology more effective for teaching and learning than traditional classroom approaches?
- Is the technology more motivating?
- Can the technology be used to increase access or reduce cost within the education? - This point is high on the agenda of Government policy makers.

Entertainment in education through multimedia takes care of all the above concerns of parents. Moreover, multimedia in education reflects business and corporate interests.

'Bringing the electronic media into the schools could capitalize on the strong motivation qualities that these media have for children. Many children who are turned off by school are not turned off by one or another of the electronic media; quite the opposite. An educational system that capitalized on this motivation would have a chance of much greater success...... Each medium has its own profile of cognitive advantages and disadvantages, and each medium can be used to enhance the impact of others.' (Greenfield, 1984, p. 178)

Table 2.1: Old versus new assumptions about learning

Old Assumptions	New Assumptions
1. People transfer learning with ease by learning abstract and decontextualized concepts.	1. People transfer learning with difficulty, needing both content and context learning.
2. Learners are receivers of knowledge.	2. Learners are active constructors of knowledge.
3. Learning is behaviorist and involves the strengthening of stimulus and response.	3. Learning is cognitive and in a constant state of growth.
4. Learners are blank slates ready to be filled with knowledge.	4. Learners bring their own needs and experiences to learning situations.
5. Skills and knowledge are best-acquired independent of context.	5. Skills and knowledge are best acquired within realistic contexts.
	6. Assessment must take more realistic and holistic forms.

2.2 COMPUTER AS PART OF EDUTAINMENT

- IT(*) and Computer are always used to create edutainment contents because it's easy to create the interactive contents and animate pictures. Almost every imagine can be realized in computer. Computers as tutors have positive effects on learning as measured by standardized achievement tests, are more motivating for students, are accepted by more teachers than other technologies, and are widely supported by administrators, parents, politicians, and the public in general. Students are able to complete a given set of educational objectives in less time with Computer Based Interaction than needed in more traditional approaches. A more robust finding for computer-based instruction is that students are able to complete a given set of educational objectives in less time with CBI than needed in more traditional approaches (Kulik & Kulik, 1991). The timesavings factor was first identified in military training contexts where a consistent 25% to 50% reduction in time to train has been demonstrated when interactive technologies are employed (Fletcher, Hawley, & Piele, 1990). The pressure to save instructional time has not been as great in school contexts, a situation that may change if proponents of national assessments are successful, and teachers perceive the need to cover more content within the school year.

(*) A IT (information technology) is a term that encompasses all forms of technology used to create, store, exchange, and use information in its various forms (business data, voice conversations, still images, motion pictures, multimedia presentations, and other forms, including those not yet conceived). It is the technology that is driving what has often been called "the information revolution."

Table 2.2: Summary of the educational values of multimedia computers

	Educational Value	Digital Integration
Metaphor or perspective	understand and simplify by comparison and contrast with different points of view as represented by different senses through different media	the digital format requires schools to teach skills with a wide array of composition and communication applications to address tactile, aural, visual and potentially other senses
Variation	change that grabs and maintains attention	changing and integrating the media of print, still images, animation, video, 3D/virtual reality and audio
Awareness	• sense what you have not previously known • replacement for a sense or senses disabled • greater cultural relevance	tactile, aural, visual, electronic sensors, remote control of digital devices, other interaction variations including email and web form pages
Community economy	workforce preparedness with digital communication, calculation and composition	all forms of multimedia and unimedia

2.3 INTERACTIVE LEARNING ENVIRONMENT

The field of edutainment has witnessed tremendous growth in research and development of interactive multimedia learning environments in recent years, especially computer-based environments. Researchers and developers are struggling to find innovative ways to exploit the interactive potential of the learning environments afforded by computers while remaining consistent with psychological and philosophical beliefs about how people learn and the practicalities of learning in schools and the work place. An essentialist view of education maintains that there are things that everyone should know and the best way to achieve this learning is through careful curriculum planning that is rigidly enforced. In this transmission model of education the "all knowing" teacher is expected to deliver or transmit the knowledge society believes its citizens need to know. However, many now feel this demeans teachers by technicizing their role in the classroom. A view holds that any attempt for one group of people to make decisions (e.g. teachers) on what another group of people should learn (e.g. students) is at best misleading and at worst unethical. Educationally speaking, there are little or no rules here. Given the serious work and thought evident in these areas, it is somewhat surprising that one of the most fundamental and important concepts of human interaction has received so little attention by our field - play. Perhaps it is because the word "play" can invoke so many misconceptions. Research from education, psychology, and anthropology suggests that play is a powerful mediator for learning throughout a person's life. The time has come to couple the ever-increasing processing capabilities of computers with the advantages of play. Microworlds, simulations, and games are the attributes of three well known learning environments (or strategies) consistent with play. A careful blending of their attributes offers promise in guiding the design of interactive learning environments where structure and motivation are optimized without subverting personal discovery, exploration, and ownership of knowledge. In other words, learning environments that encourage people to play.

Note: The thesis is aiming to make a microworld, which is one of the attributes of learning environment.

2.3.1 Overview of play

An understanding of the philosophical assumptions of play is a critical first step to understanding its role or value in learning and instruction.

Play is generally defined as having the following four attributes:

1) It is usually voluntary
2) It is intrinsically motivating
3) It involves some level of active, often physical, engagement
4) It is distinct from other behavior by having a make-believe quality.

Child's play is an engaging and deliberate activity in which they devote great effort and commitment. Another misconception is that the activity of play is irrelevant or inconsequential to either formal or informal learning. Extensive research on play with children and adults in anthropology, psychology, and education indicates that play is an important mediator for learning and socialization throughout life. The benefits of play are long-term - enabling intellectual and social growth over many years.

Current theories of play are generally organized around four themes: Play as progress, play as power, play as fantasy, and play as self. Play as progress is a means to improve or enable psychological or social needs. This type of play is almost always described as an important mechanism by which children become adults, thus strongly suggesting a clear distinction between children's play and adult play. Play as power refers to contests or competitions in which winners and losers are declared. Examples are a game of football, chess etc. Play as power belongs almost exclusively to adult forms of play. Play as fantasy refers to play's role in liberating the mind to engage in creative and imaginative thinking. There are some obvious connections here to play as progress as when one views creativity as an outcome to be pursued as opposed to a state to be intrinsically valued. Play, as self is the most recent of themes. It places value on play's role as a way to achieve optimal life experiences. One important point is that play should not be idealized. Despite its many advantages, one should avoid the view, commonly referred to as the "play ethos," that all play is good. Similarly, it is naive to think that play

always involves solely voluntary participation.

2.3.2 Microworlds

Microworld is a small, but complete, version of some domain of interest. People do not merely study a domain in a microworld; they "live" the domain, similar to the idea that the best way to learn Spanish is to go and live in Spain. Microworlds can be naturally found in the world or artificially constructed (or induced).

At first glance, computer-based microworlds are often confused with simulations. However, microworlds have two important characteristics that may not be present in a simulation. First, a microworld presents the learner with the "simplest case" of the domain, even though the learner would usually be given the means to reshape the microworld to explore increasingly more sophisticated and complex ideas. Second, a microworld must match the learner's cognitive and affective state. Learners immediately know what to do with a microworld - little or no training is necessary to begin using it (imagine first "training" a child how to use a sandbox). In a sense, then, it is the learner who determines whether a learning environment should be considered a microworld since successful microworlds rely and build on an individual's own natural tendencies toward learning. It is possible for a learning environment to be a microworld for one person but not another. In contrast, a simulation is determined by the content or domain it seeks to model and is usually judged on the basis of its fidelity to the domain.

The two dominant characteristics of microworlds (i.e. "simplest case" of a domain; match the user) present a large set of complex assumptions and expectations for a would-be microworld designer to meet. Among the most important is that learners are expected to ***self-regulate*** their own learning in a microworld. Self-regulated learning is when a person takes responsibility for their learning and, as a result, takes appropriate action to ensure that learning takes place.

2.3.2.1 Self-regulation

Self-regulated learning has three main characteristics. First, learners find the environment to be intrinsically motivating, that is, they find participating in the activity to be its own reward and do not seek or need external incentives. Second, self-regulated learners are met cognitively active. Learners actively engage in planning and goal-setting and are able to monitor and evaluate their own learning. Third, self-regulated learners are behaviorally active in that they take the necessary steps to select and structure the environment to best suit their own learning styles. Learner control is essential for self-regulated learning. Few psychologists or educators would dispute the argument that the most effective learners self-regulate their own learning. Disagreements arise; however, it may be more useful to describe conditions, which may lead to self-regulated learning. For that reason, two theoretical frameworks describing the underlying conditions of self-regulated learning in a microworld are briefly considered at this point: components of Piaget's theory of intellectual development and the Flow Theory of Optimal Experience developed by Mihaly Csikszentmihalyi. Both illustrate the close relationship between self-regulated learning and play.

2.3.2.1(a) Piagetian Learning Theory

Piaget's theory is characterized by the four developmental stages (i.e. sensorimotor, preoperational, concrete operations, and formal operations), self-regulated learning in a microworld is most closely based on the stage independent part of Piaget's theory which can be summarized by the following three properties: epistemic conflict, self-reflection, and self-regulation. Epistemic conflict denotes an ongoing cognitive "balancing act" by each individual. On one hand, we each seek an organized, orderly world, but we are continually confronted with an ever-changing environment. Self-reflection involves an individual's deliberate attempt at assessing and understanding a given situation. However, only through self-regulation will an individual arrive at a resolution or solution to the conflict. Either the conflict is resolved as fitting an established mental structure (i.e. assimilation), or a new structure is formed (i.e. accommodation) (a third possibility is that the conflict remains unresolved and no learning takes place).

According to this theory, learning cannot occur unless an individual is in a state of disequilibria (i.e. mental structures not in "balance"). Learning is defined as the construction of new knowledge resulting from the resolution to the conflict. Piaget theorized that knowledge was always transitory, continually shifting in shape and form. Piaget referred to individual mental structures as "schemes." Assimilation is the process of understanding the world through existing schemes, whereas accommodation is the process of building new schemes (based on refinements and blending of existing schemes) (Phillips, 1981; Piaget, 1952). The purpose of a microworld is simply to foster, nurture, and trigger the equilibrium process (Dede, 1987; Papert, 1980, 1981). It is important to note that Piaget's theories have recently been criticized for neglecting social and cultural influences on cognition and are often contrasted with the theories of Vygotsky. Attempts have been made to reconcile these differences by suggesting that Vygotsky and Piaget offer complementary rather than competing views (see Fowler, 1994).

2.3.2.1(b) Flow Theory.

The Flow Theory of Optimal Experience developed by Mihaly Csikszentmihalyi (1990) focuses exclusively on adults. Though rarely considered by instructional technologists flow theory provides an important framework for an adult's motivation for learning. Flow theory gets its name from the way so many adults have described a peculiar state of extreme happiness and satisfaction. They are so engaged and absorbed by certain activities that they seem to "flow" along with it in a spontaneous and almost automatic manner - being "carried by the flow" of the activity. Csikszentmihalyi (1990, p. 4) defines flow as"...the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it."

Attaining flow is not necessarily easy and rests on certain conditions and skills. For example, people who experience flow must have the ability to focus attention, to concentrate without distraction.

One result of flow is psychological growth, that is, the individual becomes more complex or elaborate. The psychological mechanisms that account for growth are differentiation and integration. Differentiation is the need for the individual to remain unique from others whereas integration is the need to feel connected to other people and other ideas. These seemingly opposite processes work together to achieve a state of balance between goals and expectations, not unlike the Piagetian process of equilibration.

Flow derives from activities that provide enjoyment (as compared to mere pleasure). Enjoyment results when an activity meets one or more of the following eight components: 1) challenge is optimized; 2) attention is completely absorbed in the activity; 3) the activity has clear goals; 4) the activity provides clear and consistent feedback as to whether one is reaching the goals; 5) the activity is so absorbing that it frees the individual, at least temporarily, from other worries and frustrations; 6) the individual feels completely in control of the activity; 7) all feelings of self-consciousness disappear; and 8) time is transformed during the activity (e.g. hours pass without noticing). Not surprisingly, these components are quite consistent with characteristics of gaming.

Optimizing challenge is particularly important in order to experience flow. People must constantly be able to match challenge with their current skill or ability. If one's skill is low in an activity (such as tennis) and the challenge is too high, then the individual will enter a state of anxiety. If an expert tennis player is playing the game with a novice because of a desire to teach the game, flow may be derived not from the act of playing the game but from the satisfaction of the student's motivation and progress. Of course, as an individual's skill or ability increases, they need to increase the challenge accordingly. Flow is only possible as long as a person avoids boredom and anxiety simultaneously.

Finally, Csikszentmihalyi stresses that transforming ordinary experience into flow demands effort and work. One does not attain flow by being passive. However, the ability to reach optimal experience can be improved over time with deliberate effort. Csikszentmihalyi also warns of the danger of addiction, when the desire to participate or engage in an activity is so consuming that the quality of one's life actually deteriorates (e.g. obsessive gambling or drug addiction).

2.3.2.2 Simulations and Games in the Design of Microworlds

Of course, it is easy to demand self-regulated learning as a "requirement" for a successful microworld, it is quite another to describe how to design a microworld that supports and encourages a self-regulated learning process. As already mentioned, finding an appropriate objectivist methodology is difficult, if not misguided, due to the critical and unpredictable role of each individual learner. Despite this, characteristics of simulations and games may provide some practical means of meeting the assumptions of a successful microworld. Both offer extensions of critical parts of the psychology underpinning the constructivist nature of microworlds, while also providing some of the inherent structure called for by most objectivists. Simulations offer a direct link to the subject matter or content; and games offer a practical means for meeting the microworld assumption of self-regulation. Games in particular offer many intriguing psychological and social insights to microworld design and for that reason their value is underscored.

Chapter 3
Back Ground Research –2
Indus Valley civilization

Indus valley civilization was chosen as historical content to build a microworld in computer. Why Indus valley worth considered for building microworld?

- Anthropology informs us that all peoples and places are worthy of study, since the collectivity of humankind, in all our historical depth and geographical spread, is the only complete documentation of human diversity, cultural and biological – and that is what anthropology is all about.
- Over the past eighty years or so, a number of interesting observations have been made concerning the peoples of the Indus Age and their sociocultural systems. These observations set the Indus Age and the Indus Civilization apart in quite specific ways from other peoples and places. These observations are used to provide structure and coherence for the microworld, which is built.
- Need of the society to know the values Indus Age knowledge can offer to their life.

3.1 ORIGIN OF INDUS VALLEY CIVILIZATION

Some 4600 years ago, i.e., about 2600 years before the birth of Jesus Christ, a highly developed civilization, known as the Indus Valley or Harappan Civilization, existed along the rivers the Indus and Saraswati. Nothing of this civilization was known until the early part of this century, when two archaeologists Dr. D.R.Sahni and Dr. R.D. Banerjee discovered Harappa and Mohenjodaro (both in Pakistan now) in 1921 and 1922 respectively.

Indus civilization claims a larger area than any of the known pre-classical civilization. Its northern border is Manda in Jammu. Its southernmost limit is Daimabad in Maharashtra. The eastern limit stretches upto Hulas in U.P. and the western limit upto

Suktagendor in Baluchistan. From north to south it covered an area of 1600 kms and from east to west about 960 kms, the axis of Egypt and Mesopotamia was less than 960 kms. Of several sites, the two Harappa and Mohenjo-daro, are very large.

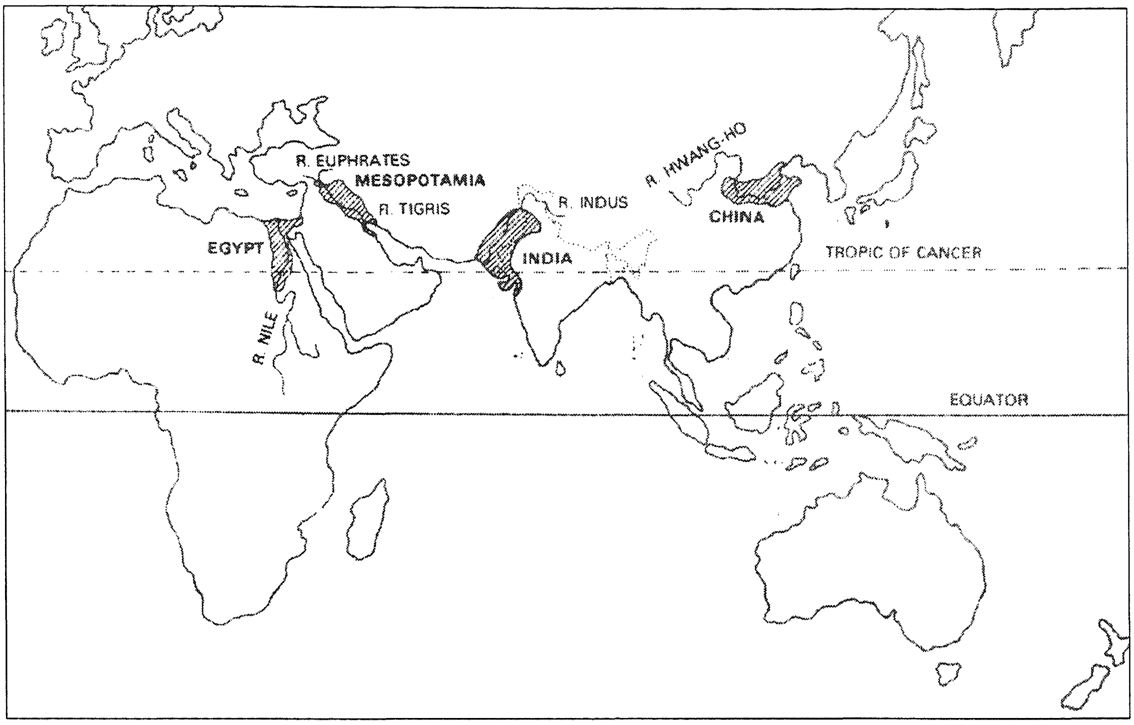


Fig.3.1: River Valley Civilizations

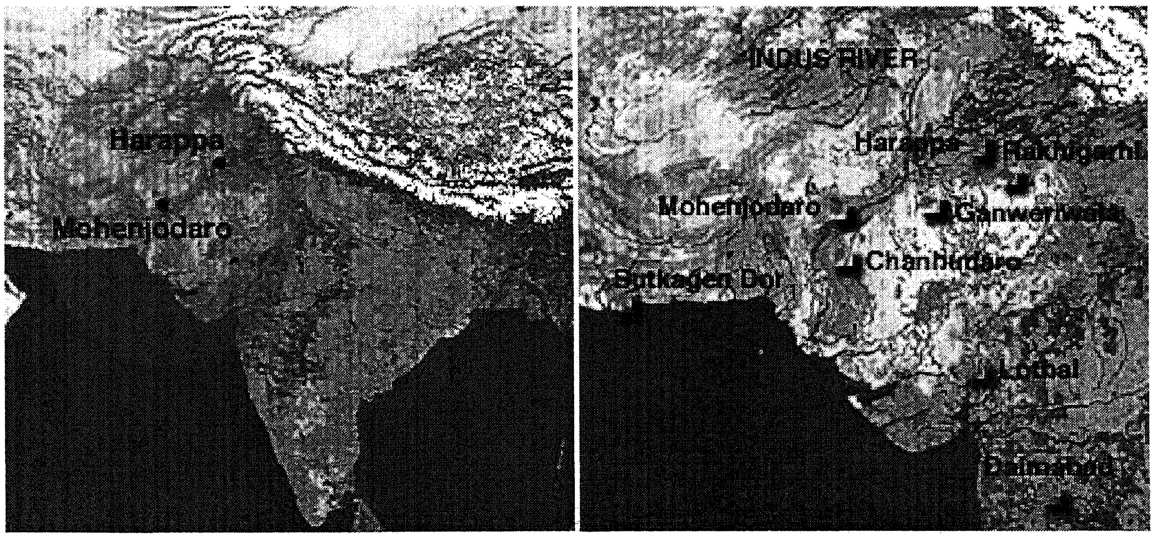


Fig.3.2: Extent of Indus Valley Civilization

3.2 TOWN PLANNING AND ARCHITECTURE

3.2.1 Streets

The cities of the Indus are the earliest sites yet discovered in the world where a scheme of planning existed. There is no evidence of such a scheme at Ur, Babyon or Egypt at about that date. The Indus cities were built on prearranged plans as is evident in the case of Mohenjodaro, which is very well preserved. There was some kind of municipal or civic authority, which controlled the development of the city. The streets ran in straight lines and crossed one another at right angles. The streets were aligned from east to west or from north to south. The most famous street, called the 'First Street' of Mohenjodaro, was 35 feet wide and would have accommodated seven lines of wheeled traffic simultaneously. The other roads were 13' to 12' wide, while the lanes and alleys were 4' upwards.

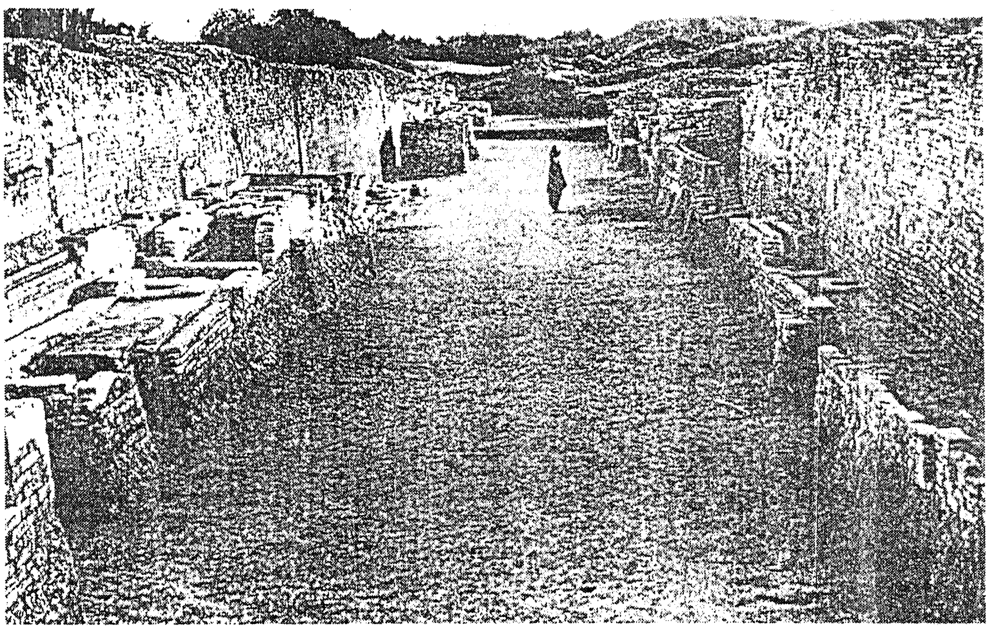


Fig.3.3: View of First Street

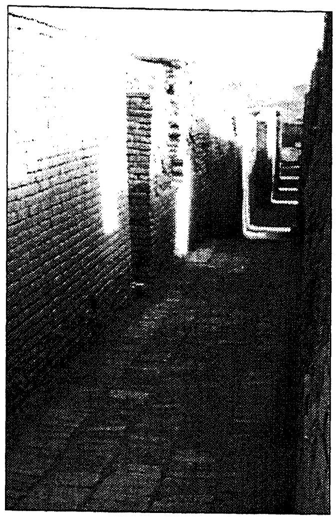


Fig.3.4: Lane between the Houses

3.2.2 Buildings

The buildings were plain, only in the floor of one house at Kalibangan and another at Balalcot the ornamental bricks were used. Probably the verandas were decorated with wooden screens which have now perished. The ground floor of a small house measured 27x30 feet and the large one was double its size. The houses were mostly separated from one another by about a foot probably to avoid dispute with the neighbour, and the space in between was bricked up at either ends to prevent the thief from scaling the walls. The walls were very thick which suggests that some of the houses were double storeyed. Square holes on the walls remind that the upper floors and roof rested on wooden beams. The roofs were made of reed matting and then covered with thick coating of mud. To drain out the rain water gutters of pottery were made; a number of them have been found at Chanhudaro. No roof tiles have so far been traced.

3.2.3 Lighting Arrangement

A pottery candlestick answers how the houses were lighted. No lamp or other receptacles have been traced. Some vegetable oil or animal fat must have been used to lit the lamp. It is interesting to learn that the candlesticks were employed at such an early date.

3.2.4 Foundation Deposits

Harappans did not use foundation deposits, a custom prevalent in Babylonia and Egypt. Such deposits help the excavator to fix the date or history of the building. Similarly, nothing is known about ceremonies associated with the laying of foundation.

3.2.5 Bricks

Harappa, Mohenjodaro and other major towns were built entirely of bricks- a large quantity of which was properly fired. All the bricks, burnt or unburnt, were well proportioned. They were twice as long as they were wide and half as thick. On an average the bricks were 10.25 x 5.0 x 2.5 inches. Very large bricks measuring 20" or more were used to cover drains. The later occupants sometimes removed the bricks of the old houses and reused them. It was possible owing to the non-sticking nature of the mud.

3.2.6 Furniture and Fixtures

The floors were generally of beaten earth coated with cow dung. The huge pottery jars must have served for storage. Deep recesses on the walls suggest that they were once fitted with wooden chest. Beds and stools were the articles of furniture, traces of which have been found at Kalibangan and Banawali. Shiva, in the famous so-called "Pashupati Seal", is sitting cross-legged on a couch.

3.2.7 Doors and Pillars

The houses had no windows-light and air passed through the doorways. The doors were set in wooden frames. A corbelled arch crowns the only doorway whose top has survived. The average width of the door was 3 feet 4" though the widest door measures 7 feet 10".

3.2.8 Drainage System

The drainage system, as demonstrated at Mohenjodaro and Chanhudaro, is the most complete ancient system as yet discovered. Every street had its bricks-lined drainage channel to which were connected the smaller tributary drains from the houses on either side. The main channels were 12 inches deep and 9 inches wide. They were mostly made of brick with mud mortar although lime and gypsum was also used occasionally to make it more watertight. The drains were covered with loose bricks, which could be easily removed for cleaning. Larger brick culverts (5' long, 2' wide) with corbelled roofs were constructed on the outskirts of the city to carry away storm water. The rainwater culvert at Mohenjodaro is an excellent example of sanitary engineering.

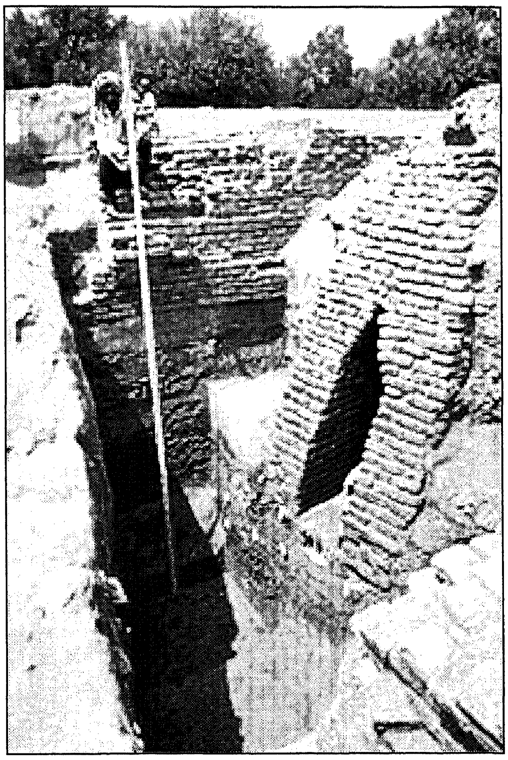


Fig.3.5: Large corbelled drain was built in the middle of an abandoned gateway at Harappa to dispose of rainwater and sewage.

3.2.9 Life Style

On 'saddle quern' grain was ground and in 'curry-stone' herbs were pounded and certain food grains dehusked. Animals like dogs, cows, oxen lived with men in the same house for many feeding pans have been excavated.

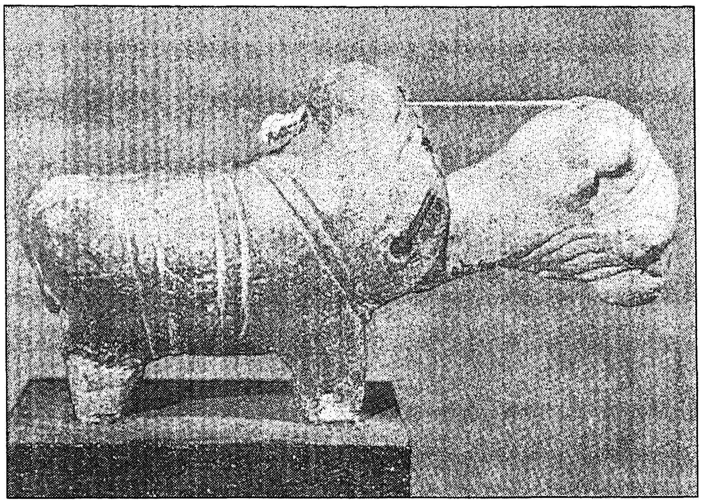


Fig.3.6: Toy Bull

3.2.10 Toilet and Bathroom

Every house had its bathroom which was on the side of the street. Latrine, though found rarely, lay between the bathroom and the street for the convenient disposal of faecal matter with the aid of waste usually through a chute. The bathroom and latrines on the first floor had brick channels.

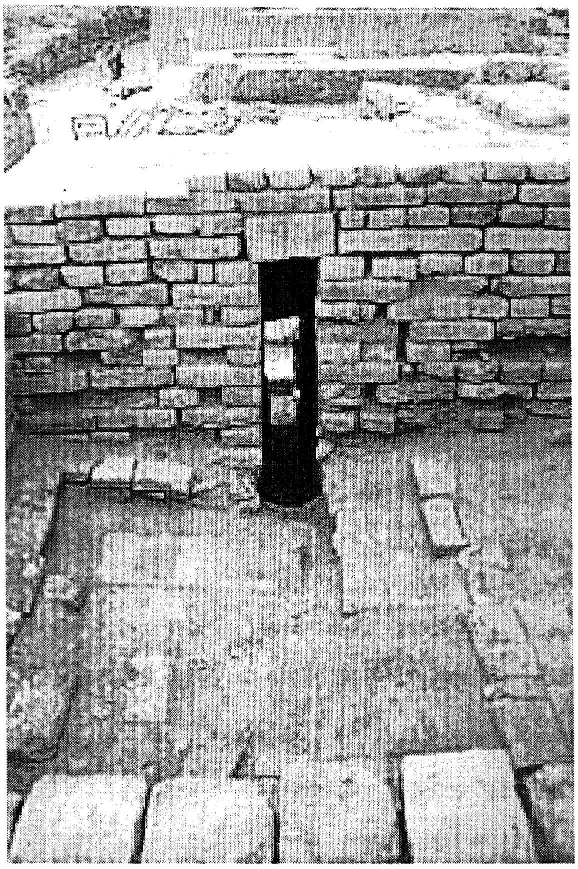


Fig.3.7: drains to take the dirty water out into a larger drain
that emptied into a sewage drain bathing areas had water tight floors

3.2.11 Great Bath

The great bath (40 feet x 23 feet) at Mohenjodaro is constructed entirely of burnt brick. It has staircases 9" rise and 8" tread on two shorter sides. Immediately below the stairs is a broad platform (39" wide, 16" high) - a safe bathing place for children. There are eight bathrooms, each room, carefully paved, has a drain for carrying off the water. Traces of a stairway were found which led to an upper storey, now destroyed. This building was for priests, each living in a room above his bathroom. There is a large oval well which supplied water. Bathing was a ritual. Great Bath was perhaps used on ceremonial occasions.

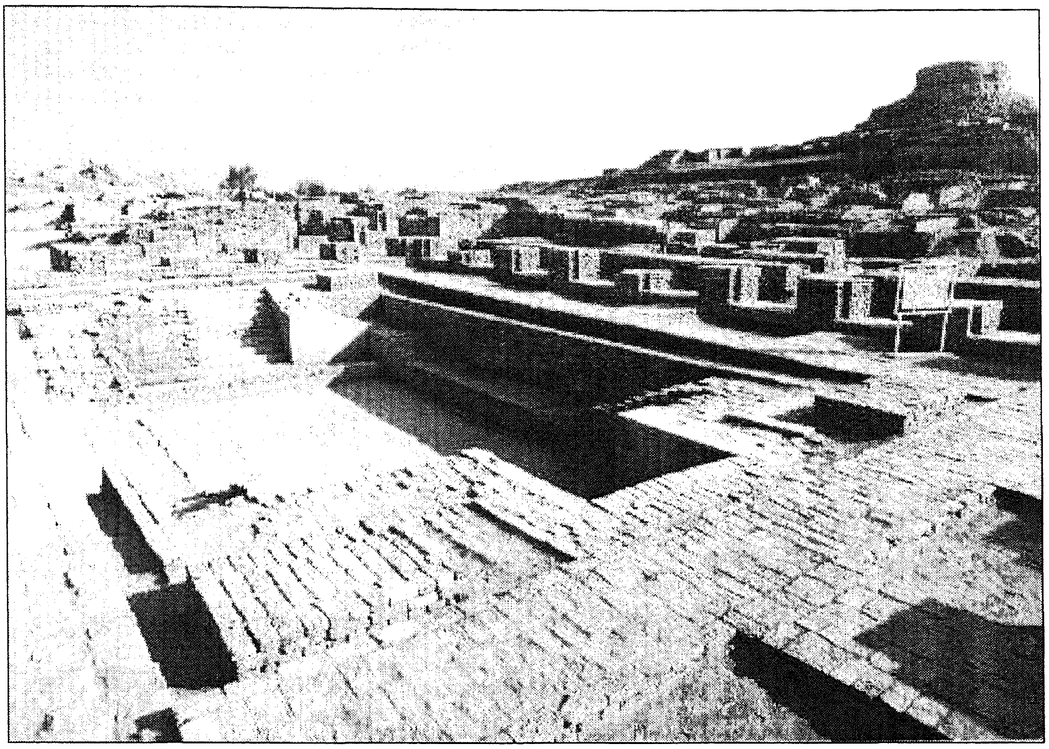


Fig.3.8: Great Bath Mohenjo-daro

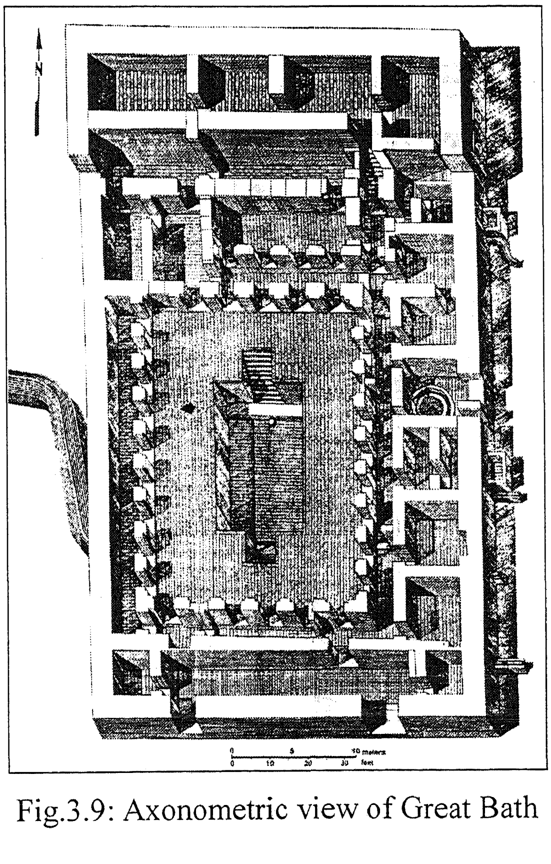


Fig.3.9: Axonometric view of Great Bath

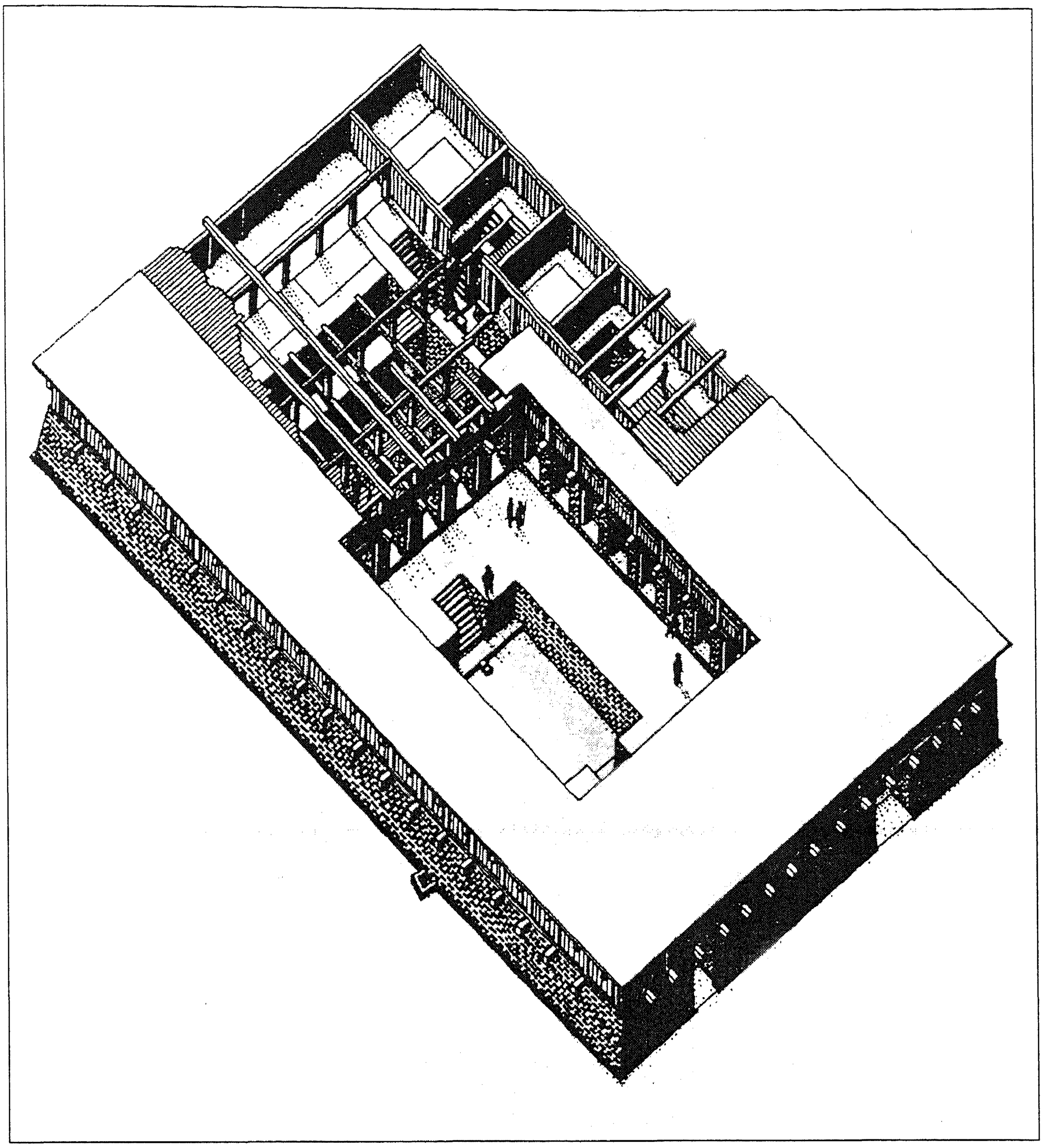


Fig.3.10: Reconstruction of Great Bath

3.2.12 Palace

A short distance from the 'First Street' was a palatial building of excellent masonary. It has two spacious courtyards, servant quarters and store rooms. It is 220 feet x 115 feet with 5 feet thick walls. The outer walls are 22 feet high. It was either a temple or the residence of the governor.

3.2.13 Granary

In Harappa has been discovered a building, 168 feet x 134 feet, with a central passage 23 feet wide. It was a gigantic store house for grain, cotton or other merchandise. Some buildings were used as eating houses which have depressions in the floors which once held large pottery jars for liquids, grains and other food stuffs. This area has been interpreted as a working area where grains were dehusked in a wooden mortar with a wrestle, the former being fitted in the aforesaid depressions.

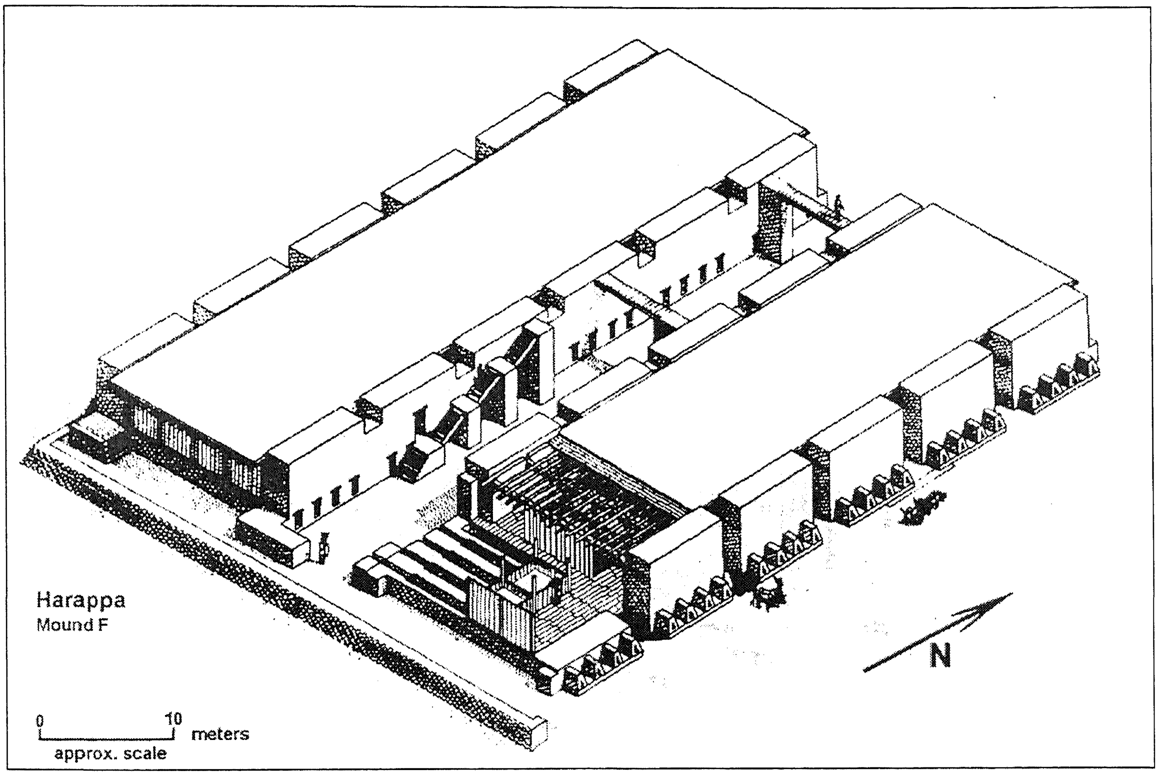


Fig.3.11: Granary at Harappa

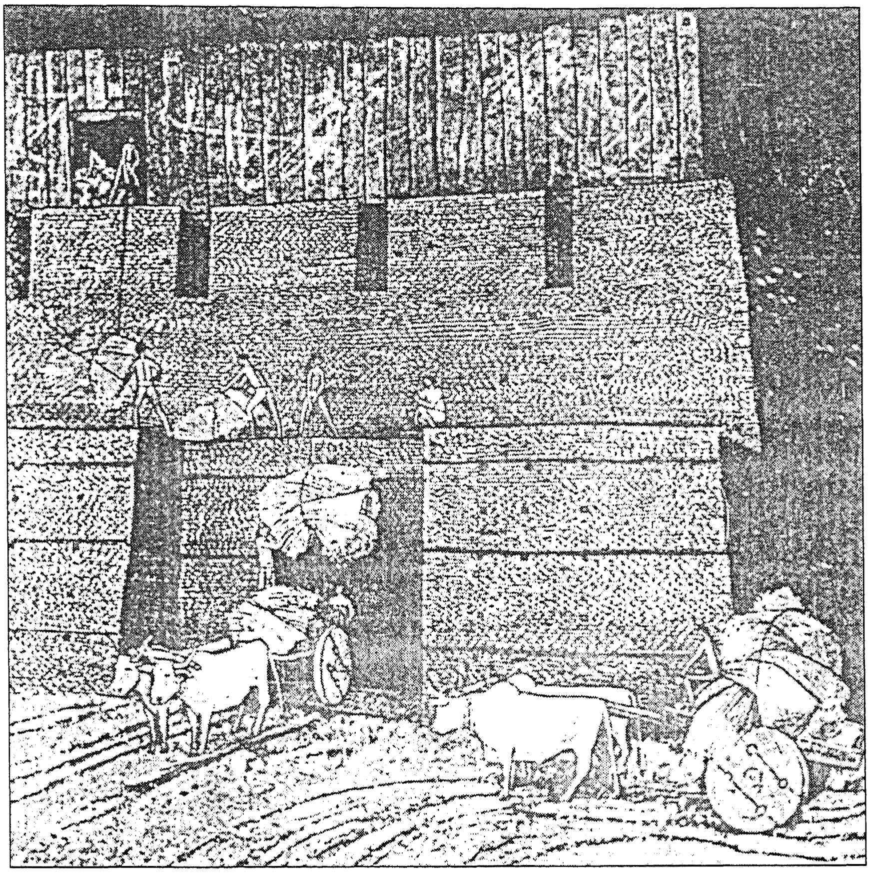


Fig.3.12

3.2.14 Assembly Hall

On the south of the later stupa in the citadel of Mohenjodaro has been discovered a hall, 85 feet square, with a roof having 20 rectangular brick piers in 4 rows of 5 piers each. Four well paved aisles are separated by rows of pillars. The hall was used for some religious assembly.

3.2.15 College

Several dwelling houses, large and small, have been unearthed at Mohenjodaro. There were large *khanas* (inns), storehouses and watchtowers. There is an extensive building, on the west of the stupa mound, which measures 230 feet x 78 feet. Sir John Marshall excavated it.

3.2.16 Population

The population of the city gradually increased and the big houses were divided into smaller ones. In later stages civic rules were not strictly adhered to. A 'city wall' protected the entire city. A small fort has been laid bare in most of the important cities.

The Harappan buildings were far behind in beauty, refinement and decorative values. All buildings are plain and simple, strictly utilitarian.

3.3 SOCIAL CONDITION

An important characteristic of the Indus civilization was its urban life. The rural areas not only supported but often contributed to the socio-cultural development at the urban-rural level. The Indus civilization reflects a highly developed civic life. Lack of any outstanding monument of supreme god and other supreme sacred objects suggests absence of any higher authority or totalitarian government. The society mainly consisted of middle class urban people.

3.3.1 Social Set Up

The Indus society, class-ridden as it was, included administrators, officials, priests, traders and merchants, craftsmen, landlords, peasants, herdsmen and laborers. The social position and stratification is reflected in the dwellings and the disposition of the dead bodies in the graves. The rich and elite lived in big and palatial buildings, others in smaller houses.

(i) PHYSICAL TYPES

From the bones and skeletal remains, the people can be classified into four races: (a) Proto-Australoid, (b) Mediterranean, (c) Mongolian, and (d) Alpine-the majority being the first two. People were short, the average height of the male being 5feet, 1 inch.

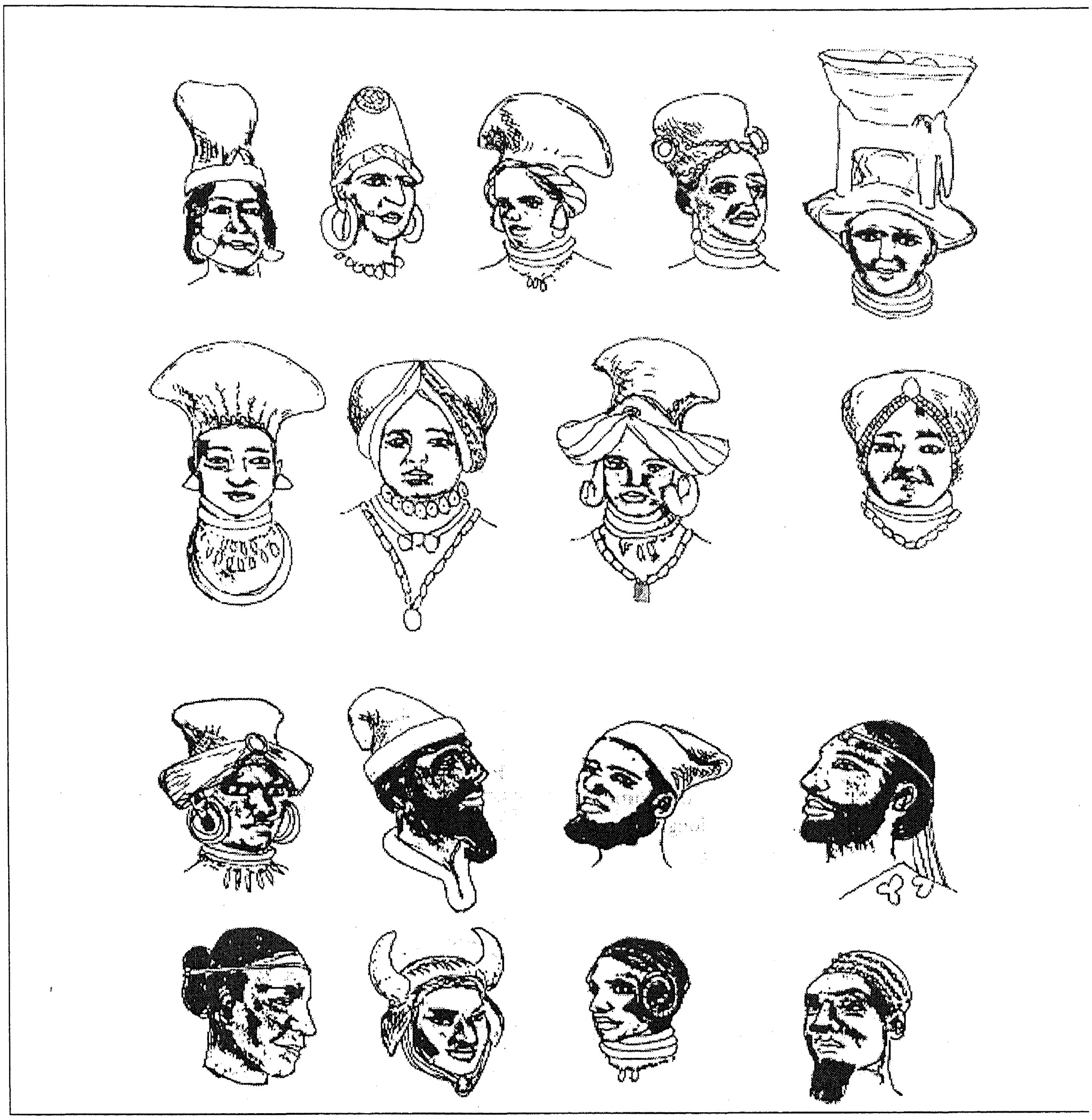


Fig.3.13

(ii) FOOD AND DRINKS

People sat on the mat to eat their food. Chairs and tables were not used. Spoons were used but no forks. There were pottery cups for drinking. Grinding-stones were for spices, curry-stones for curry and pottery moulds for cake-like breads. For digestion and health, medicinal herbs were used. From rocks *shilajit* was made which, according to the Ayurveda, is used for dyspepsia and the diseases of the liver.

Fig.3.14: Cooking vessel from Harappa

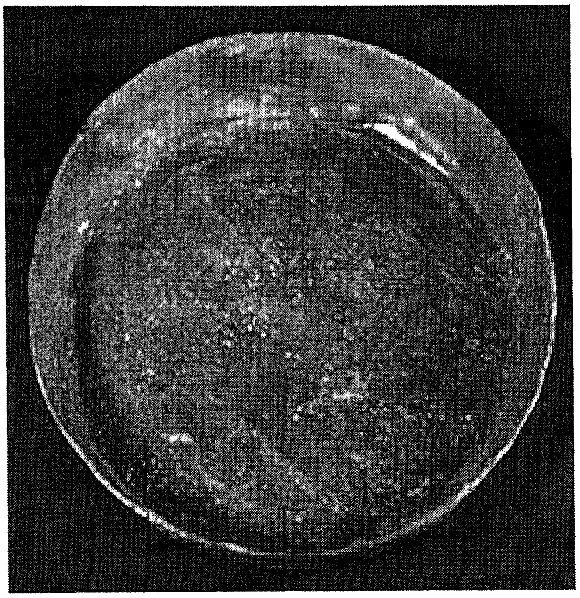


Fig.3.15: Copper plate from Harappa

(iii) KITCHEN

Kitchen was small. Fuel was placed on a raised platform. Mostly the cooking was done in the courtyards in open. Sometimes between the kitchen and the larger room a 'serving hatch' (an aperture in the wall) was made. Pottery vessels with a hole in the bottom were sunk in the kitchen for waste water. The water gradually ran into the earth. Saddle querns made of hard gritty stone were used for grinding grain. These have

pronounced convex base. Stones with large hollows were used for the preparation of curry powder.

(iv) COSTUME

The costume as revealed by the terracotta figurines of the Mother Goddess tells that the ladies were scantily dressed. They wore a short skirt that reached up to the knee. It was held by a girdle-a string of beads. The male used robe with or without embroidery. No footwear has survived nor is it shown in any of the figures. Cotton was used. There is no evidence of linen or wool though sheep and goat were known and might have provided enough raw materials.

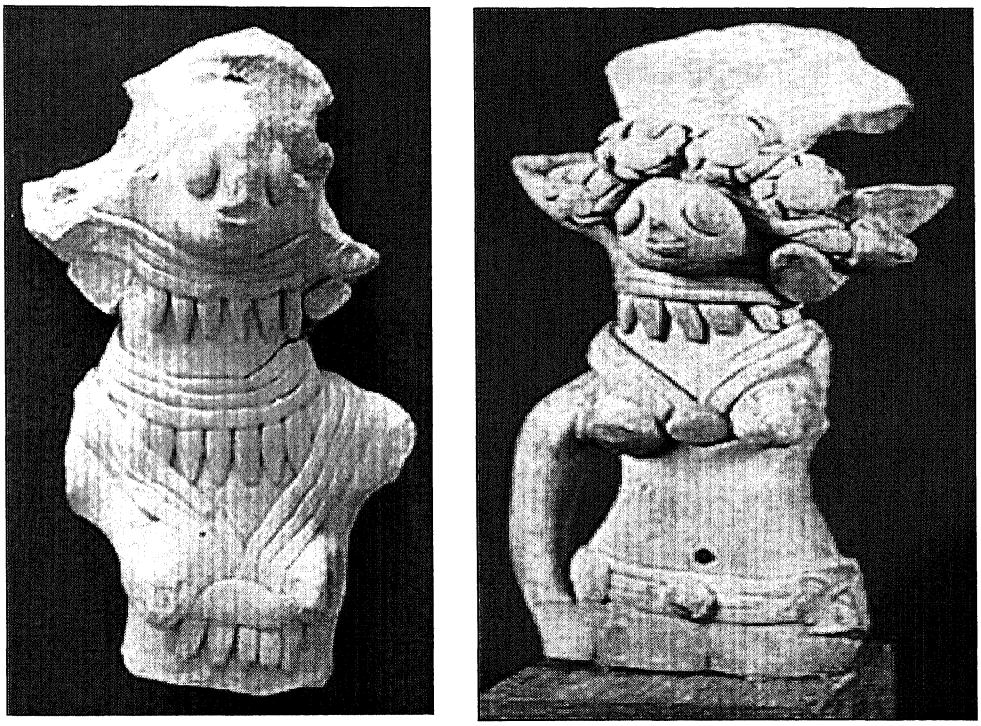


Fig.3.16: Terra-Cotta Female figurines

(v) HAIR STYLE

Women took special care of their hair. The Dancing Girl from Mohenjodaro has a pony tail. Some females have a plait tied with a bow in the end. Men had several styles of hair-dressing. Hair was parted in the middle and tied with a fillet. Sometimes the hair was gathered up in a bun or coiled in a ring on the top of the head.

(vi) COSMETICS

Round buttons of copper, bronze, steatite and faience were common. Kohl pots and sticks prove that men and women applied kohl in their eyes. Cinnabar was used as cosmetic. Minor razors, found in great numbers, were employed by men and women for depilatory purposes.

(vii) GAMES AND SPORTS

A large number of toys and objects used in games have been unearthed at all the important sites. Rattles in the form of hollow balls with pellets inside are many. Singing birds were kept in cages. A whistle shaped like a bird, a small animal climbing up the pole and models of household vessels were the pastimes of the children. Bulls with nodding heads, monkey with movable arms, figures which ran up and down a string were complex toys and must have been produced by the professional toy-makers. Dice were used in gambling. Chessmen of stone have been found.

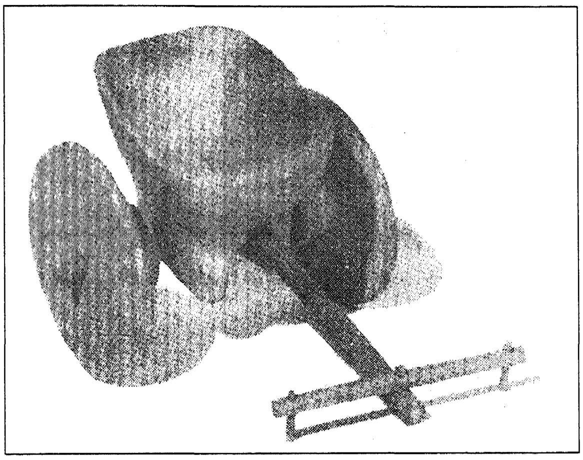


Fig.3.17: Toy Bull

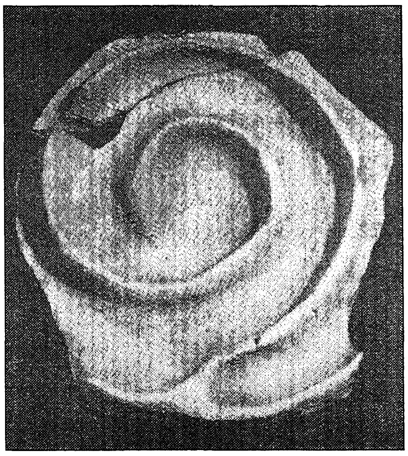


Fig.3.18: Maze Game

(viii) HUNTING AND FISHING

People enjoyed non-vegetarian food. Remains of stag, deer, rabbit, buffalo, pig, turtle, goat, ox and fish have been discovered in large quantity in many excavations. Sometimes in large jars the bones of oxen, sheep and goats, have been found. Animal sacrifice was in vogue. On a few seals, hunting of wild rhino and antelope is shown. Fishing was a regular occupation. A number of fish hooks have been found. Traps were used for mice.

(ix) MUSIC AND DANCE

A pair of castanets has been found. A drum hangs from the neck of a figure in pottery. Some of the signs of script look like harps and lyres. Music and dance were both secular and religious.

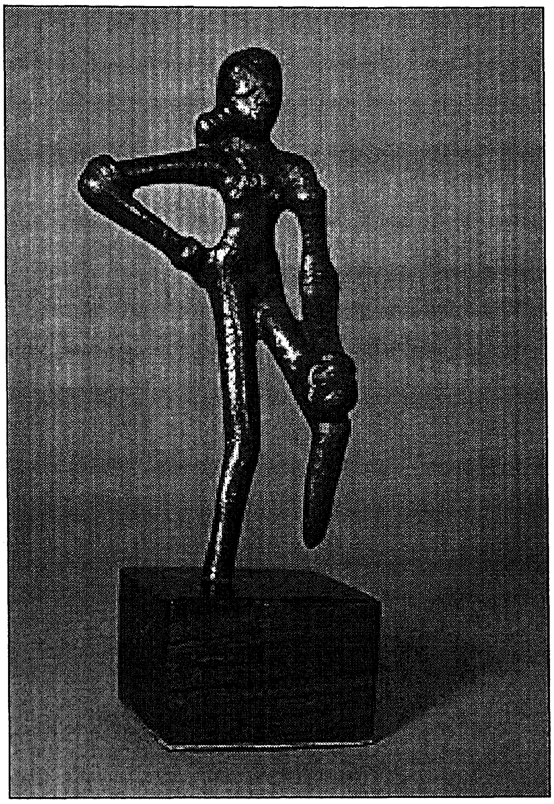
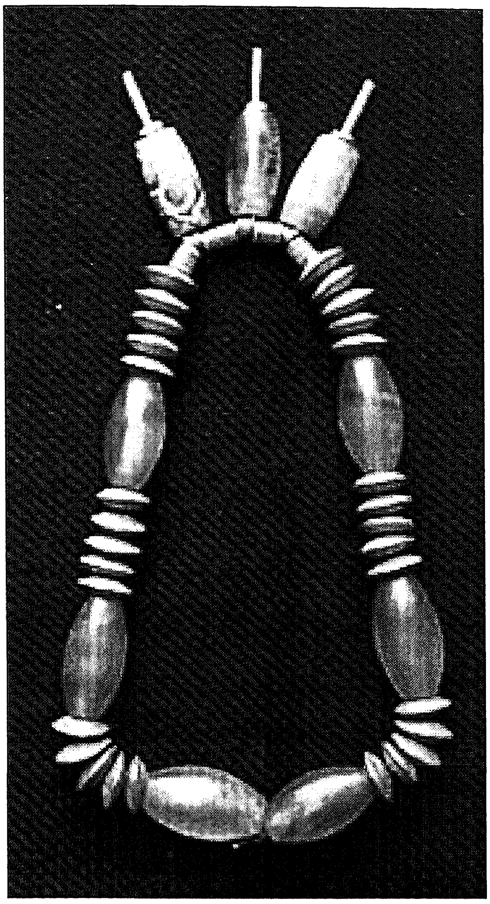


Fig.3.19: Bronze Dancing Girl

(x) JEWELLERY

Jewellery was kept for safety in the vessels of silver, copper and bronzes and was buried beneath the pavement of the houses. Many necklaces, fine stone beads, a piece of cotton, silver and gold objects have been discovered.

These ornaments were made of gold, electrum, silver, copper and bronze. Gold and silver was found within the country. Electrum, a mixture of silver and gold, also existed here. Ornaments of precious beads were produced at Chanhudaro.



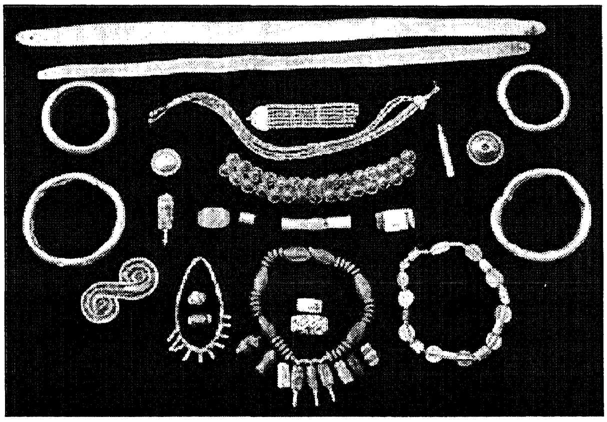


Fig.3.20: Necklace from Mohenjo-daro made from gold, agate, jasper, steatite and green stone

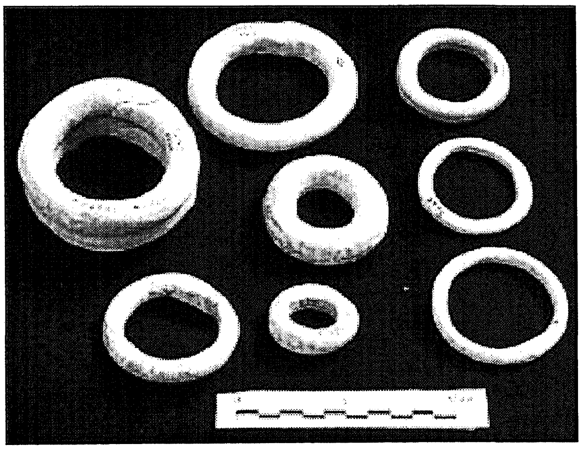


Fig.3.21: Terra-Cotta Bangles

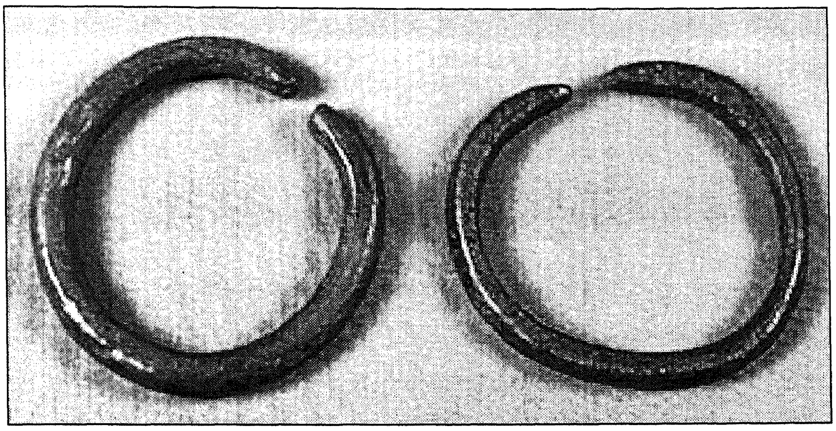


Fig.3.22: Copper Bangles

A pectoral of yellow steatite with the figure of urus bull had some religious significance. Beads of jasper, agate, onyx, plasma, lapis lazuli, chalcedony, turquoise, etc., were used for making girdles and necklaces. All these stones were obtained from different parts of India and Baluchistan. The lapis lazuli and turquoise were largely obtained from Afghanistan and South Asia. However, a gold ring has been found from the later level at Dholavira. No gold finger ring has been found-those of copper and bronze are numerous.

Nose ornaments are many. These were worn in the bored nostril. Bangles and bracelets of gold, silver, copper, bronze, faience and shell were very common. All bracelets are very plain. Anklets, though difficult to distinguish from the bracelets, were worn as has been done by the Dancing Girl. Hair-pins were very popular.

(xi) WRITING MATERIAL

The writing material in general used were bark, cotton, fabric, leather, palm leaves, etc. all of which have perished in the damp and salty soil. Writing tablets of pottery and inkpot from Chanhudaro prove that the people were educated.

(xii) INDUS SCRIPT

Short inscriptions are available on seals, tablets of pottery and copper and on a number of tools. This pictographic script has still not been deciphered. About 396 signs

have been listed. The script was written from right to left like modern Urdu. The number of signs indicates that it was not an alphabet'. It is probably syllabic.

Fig.3.23: Script on Various Seals

(xiii) BURIALS

A few cemeteries have been unearthed. In Harappa a body has been found covered with a shroud of matting and kept in a wooden coffin. It also has some items with it, probably for use in life after death. At Harappa, M.S. Vats located several such jars. Harappans usually cremated their dead on the bank of a river and the ashes were thrown into the water or interred in a grave as at dholavira.

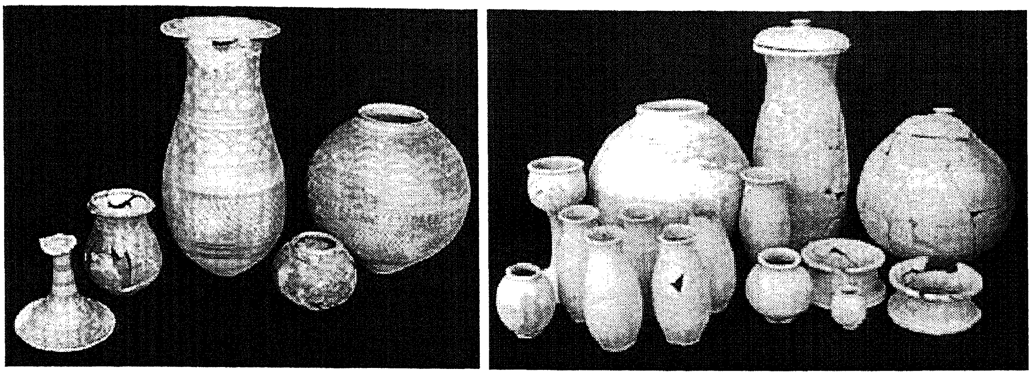


Fig.3.24: Burial Pots

3.4 ECONOMIC CONDITION

The economy of the Indus civilization was based on the irrigated agriculture which must have developed and promoted the productive forces. Representation of forest living animals on seals suggests that rainfall in Sind and Punjab was quite heavy. There is evidence of the cultivation of wheat, barley, peas, sesamum (*tila*), mustard, cotton and rice. Rice-husk and spikelets have been found embedded in clay from Lothal and Rangpur. Besides, the seeds of date and melon have also been unearthed at Harapppa. Lotus is depicted as motif on some pin-heads. They domesticated various animals (humped and humpless bulls, buffalo, sheep and goat), hunted wild animals (*sambhar*, spotted and hog deer, rhinoceros) and made various uses of several varieties of tortoise and fish. The evidence of the horse, earlier disputed, has been found in the form of bones at Surkotda (Gujarat).

3.4.1 Copper And Bronze

Copper and bronze were in abundance. Copper came from Rajasthan or Baluchistan. Tin was used as an alloy to toughen copper and also to facilitate its casting.

3.4.2 Whetstones

A few pedestals of stone, designed to support a cult object, have been found. Whetstones are very rare. These were required to polish metals.

3.4.3 Weights

Weights were made of polished chert, alabaster, limestone, quartzite, slate, jasper and other stones but chert predominates. No weight with any number or mark upon it has been found. Weights are rare.

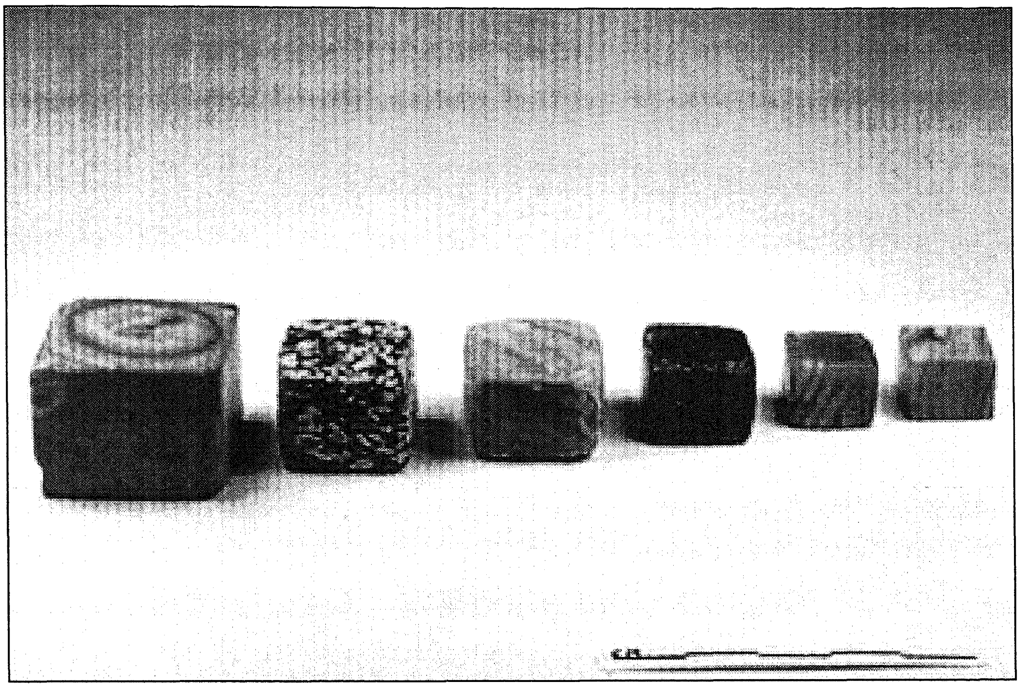


Fig.3.25: Harappan binary weights

3.4.4 Scales

Scales are very ordinary. These are bronze bar with suspended copper pans. These were used with the weights. Three measures have been discovered.

3.4.5 Cotton

Cotton was spun on spindle-whorls. Many whorls made of pottery, shell and faience, have been found. Cotton was used for textile. Needless of bronze or copper with pierced eyes or the eyes formed by looping over the top of needle itself are well known.

3.4.6 Agricultural Implements

Agricultural implements, mostly of wood, have perished. Two plough-shares of chert, 11x 4 x 4 inches, have been found. Two incomplete curved blades of copper from Mohenjodaro served as sickles. Agriculture was one of the main occupations. A completed clay model of a plough has been found at Banawali.

3.4.7 Boat-Building

A boat carved on a seal has no mast. It has a cabin and a steersman is seated at the stem. A few examples of toy boats have been found. The trade between India and the West might have been though these boats.

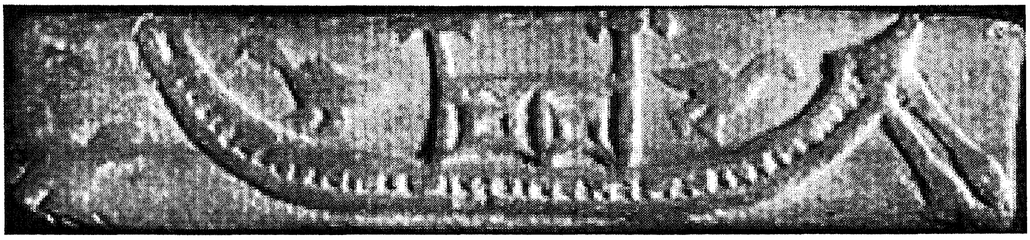


Fig.3.26: Seal which shows Boat

3.4.8 Tools And Weapons

A bronze saw, 16 inches long, with edges undulated as well as toothed, has been unearthed at Mohenjodaro. Two copper swords, each 18 inches long, again from Mohenjodaro, are in excellent condition. Spear-heads are plentiful. The largest, of thin bronze, is 15" long and 5" broad. Daggers, difficult to distinguish from knives, were long and leaf-shaped and occasionally with a rough-rib, but more often flat.

Arrow-heads, fashioned from thin sheet metal with pointed wing-like barbs, were very common. Stone arrow-heads, although largely obsolete, are occasionally met with.

3.5 ARTS AND CRAFTS

3.5.1 Stone Sculptures

There are a few beautiful stone sculptures. So far a dozen examples of statuettes have been discovered. The foremost is the priest which is discussed under 'religion'.

Two statuettes, just 4" in height, are male torsos exhibiting sensitivity and vivacity of modeling. Both are from Harappa. One of them, a dancer, was found on the granary site. It is ithyphallic and resembles a dancing Siva Nataraja.

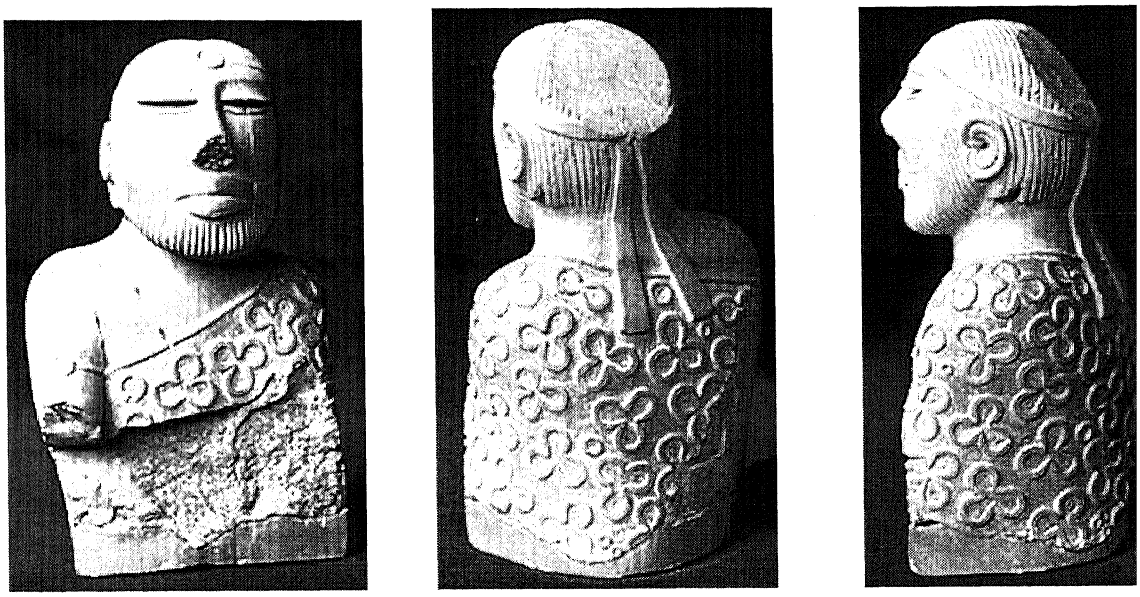


Fig.3.27: Priest King sculpture with

3.5.2 Seals

The seals with their attractive white appearance and slightly lustrous surface are the outstanding contribution of the Indus people and were used throughout the length and breadth of this civilization. Made of steatite these seals range in size from ½" to 2". Two main types are seen: first, square with a carved animal and inscription and second, rectangular with an inscription only.

The seals were very popular. More than 3000 seals have been found at Mohenjodaro alone. Below the stool are two antelopes or goats.

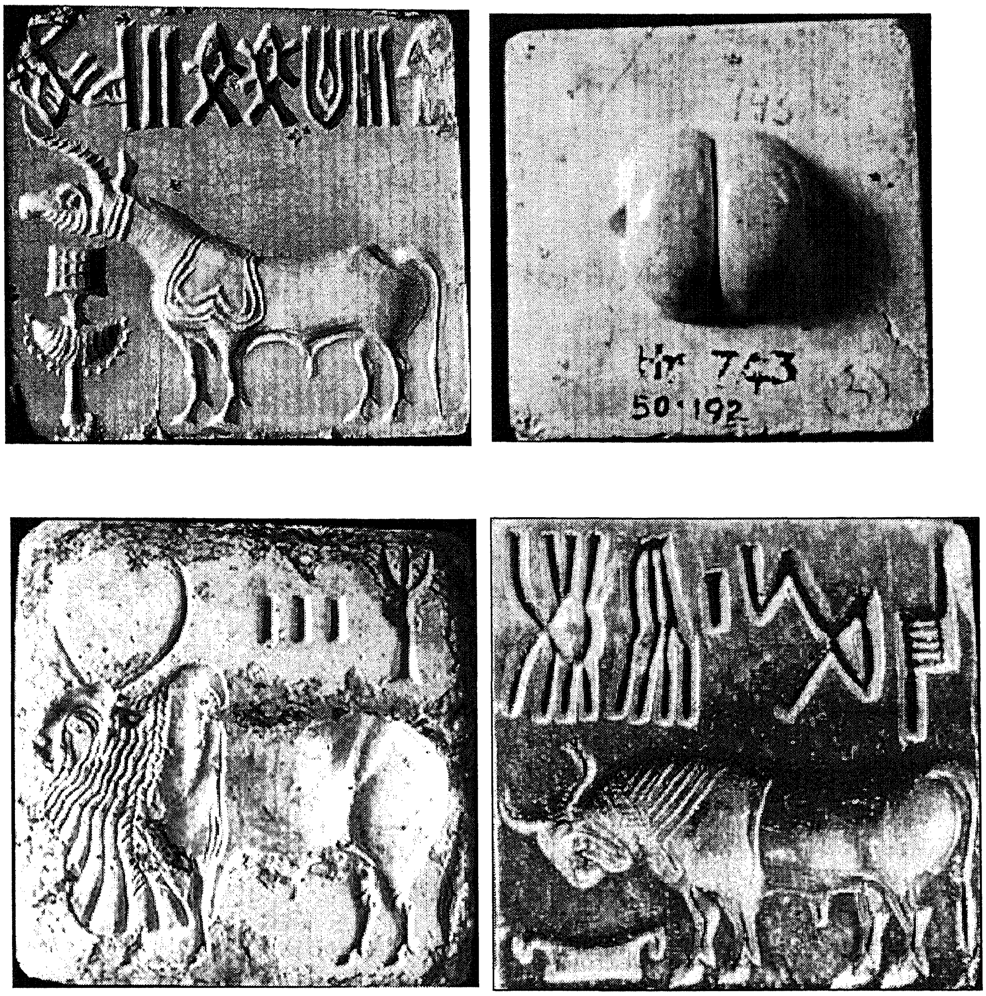


Fig.3.28: Unicorn and Bull seals

(i) BEADS

Beads are abundant and varied in form and material. They are made of gold, silver, copper, faience, steatite, semi-precious stones, shells and terracotta. In Chanhudaro a bead-maker's shop has been found. Here the processes of sawing, flaking, grinding and boring were done with chert or bronze tubular drills. Beads of steatite paste were formed by pressing the paste through fine-gauze tubes.

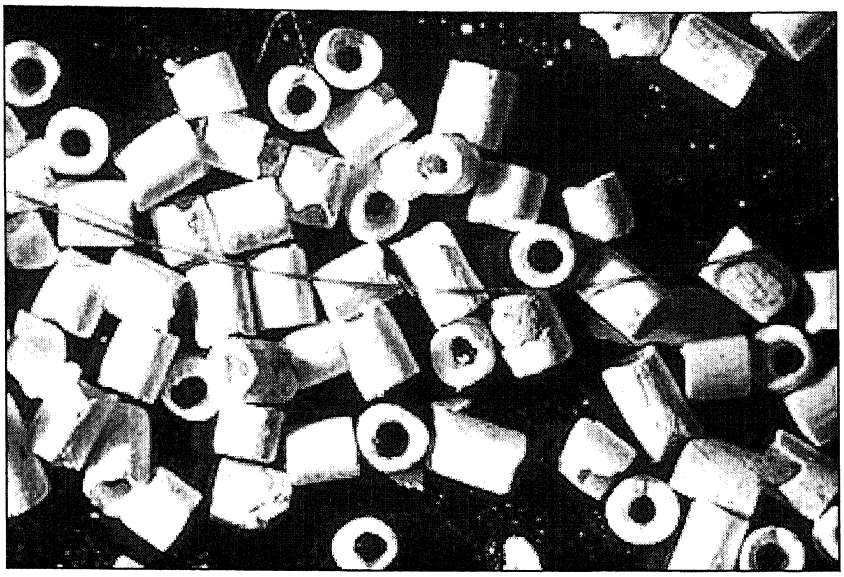


Fig.3.29: Steatite beads

(ii) SHELL AND IVORY

Shell was used as inlay or for making small objects. Articles made of mother-of-pearl are very rare; probably because it is brittle material to work on. Several conch shells were worked. Ivory was used for making dice, hair-pins and even larger objects.

(iii) STEATITE

Powdered steatite was used to mould beads and other small objects-a practice not known anywhere else. Steatite was coated with a glaze which was originally green or blue. Disc beads of glazed crystal or quartz have come to light.

(iv) TERRACOTTA FIGURINES

Terracotta figurines have been found in vast numbers at all sites. The commonest Harappa type is a standing figure adorned with a wide girdle, a loin cloth, necklaces, and a fan-shaped headdress. Women, with or without children, lying on beds, convey the ideal of fecundity. Some figures, like the one kneading flour or doing some other household chores, may be toys.

About three-fourths of the terracottas depict animals, specially the humped bull. Cows are never represented. Other animals include the dog, sheep, elephant, rhinoceros, pig, monkey, turtle and indeterminate birds. One terracotta figure from Mohenjodaro

slightly resembles a horse. Man-headed animals, often with beards, are available and these were made by hand.

Fig.3.30: Terracotta Figurines

(v) POTTERY

A large variety of pottery, both plain and decorated, have been found. All the ornamented wares are coated with an opaque red slip upon which designs were made with thick black pigment. The clay, obtained from the local river beds, was tempered with sand and contains mica or lime particles. The pottery is surprisingly identical in Harappa and other sites.

Harappa and Mohenjodaro potteries and monochromes: the Jhukar potters used two colours, red and black, on a cream or pinkish slip. The designs are conventional and mostly geometrical. In fabric, technique and design the Jhukar pottery is entirely

different. Pottery made of grey clay coated with a thick black slip and another made of light pink clay have been found, albeit rarely. Harappa pottery reveals an advanced technique. Some of these wares can be compared with the wares of Elam or Sumer.

Pot marks are rare in Mohenjodaro but very common in Harappa. No potsherd with long inscription has been found. On one potsherd the figure of a boat is scratched. Clay traps were used for catching mice and in the pottery cage chirping birds were kept as pets. Drain-pipes, wheels, spindle-whorls, bracelets, etc., were made of clay. Toys and other household articles of clay are in plenty.

(vi) METALLURGY

The Dancing Girl, 4" high, found from HR area in Mohenjodaro, is very remarkable. Her right hand rests on the hip, the left arm, covered entirely with bangles, hangs loosely and the posture of the legs is easy. She has large eyes, flat nose and bunched curly hair and gives the look of an aboriginal tribal lady. Her head is titled and feet below her ankles are missing.

Besides bronze and copper, a number of other metals such as gold and silver, lead, arsenic, antimony, lollingite and nickel were known to the Harappans. It was mostly used in unalloyed form. There is very little direct evidence of the types of ores used and the smelting processes employed by the Harappans. For manufacturing metal objects, forging fabricating techniques were employed. We do not know the probable source of silver of the Harappans, but for gold the Kolar and Hatti gold mines of Karnataka seem to be probable sources.

3.6 MAJOR CITIES

3.6.1 Harappa

Harappa, the type-site of the Indus civilization, is today a large village in the Sahiwal (earlier Montogomery) district of the Punjab in Pakistan. It has been identified with 'Hariyupiya' which is mentioned in the *Rig-Veda* .It was here that the essential makeup of the Indus cities was first recognized. The mound in Harappa was first noticed by Charles Masson in 1826 and subsequently, visited also by A. Cunningham who could not, however, understand its real antiquity. In 1921 Daya Ram Sahni surveyed it and in 1923 began the regular excavation. In 1929 it was excavated by M.S. Vats and finally in 1946 Mortimer Wheeler conducted a better organized excavation.

No clear town plan is available at Harappa today. Its important features are a citadel(460 x 215 yards), a few cemeteries, specially cemetery 'R37', furnaces and crucibles used for smelting bronze and a number of blocks of a granary (each 50 x 20 feet).

3.6.2 Mohenjo-daro

Mohenjo-daro is arguably the most impressive, best preserved Bronze age city in the world ..urbanization is a defining quality of the Indus civilization and Mohenjo-daro is the single best example of this .The layout of Mohenjo-daro is quite distinctive .There is a high mound to the west that is roughly 400meters by 200 meters(8 hectares) in size. Mohenjo-daro seems to have been a founder 's city ,built within transitional stage ,or early in the Mature harappan.It is therefore reasonable to suggest that it is in someways a complex reflection of practical day-to-day life and an expression of the ideology of the Mature Harappan .

The Planning and investment made in Mohenjo-daro over a protracted period of time informs us that it was no ordinary settlement,nor simply one among Indus urban environments.It has very extensive use of Baked brick, the great bath, site layout and town planning .

Mohenjo-daro was a placeof wealth ,more wealth than is apparent at any other Indus settlement .This wealth is expressed in terms of the continuity of civic planning and investment in urban facilities .in the high quality of architecture almost to the end ,the extensive use of baked brick,and the rich assemblage of artifacts.`

3.6.3 Chanhudaro

It is situated 80 miles south of Mohenjodaro and consists of three small mounds. It was excavated first by N.G. Majumdar in 1931 and later by Mackay in 1935. Apart from Harappa culture traces of post-Harappa culture known as 'Jhukar culture' and 'Jhangar culture' have been found here. Most of the inhabitants here were artists: many bronze and copper tools have been found in hoards. It was a great centre of bead-making, shell-and-bone-working and seal-making.

3.6.4 Suktagendor

It is situated in Baluchistan, 300 miles west of Karachi. It was first noticed by Sir Aurel Stein in 1927, and regular excavations were conducted by George Dales in 1962. There was a famous fort of stone. A pot containing human ashes, several axes of copper, bangles of clay, pottery, bird-whistle, etc., have been found here: all are reminiscent of Harappa culture. This place once played an important part in the coastal trade with Babylonia.

3.6.5 Kot-Diji

Situated 15 miles south of Khairpur town in Sind in Pakistan, it was first discovered by Chery in 1935. Regular excavation was conducted by Fazl Ahmad Khan in 1955. It has revealed a pre-Harappan culture, where the use of stone predominated. The arrow-heads of stone have been found in abundance. Probably the original settlement gutted in fire before the Harappans settled there.

3.6.6 Ali Murad

It is situated 20 miles south-west of Dadu in Sind. A massive stone fort with a well inside has been discovered. Terracotta figurines of bull, black-on-red pottery, flat bronze axes, beads of steatite, agate and carnelian and numerous terracotta cakes are identical to the specimens found in Harappa and elsewhere.

3.6.7 Rupar

It is situated in Punjab and was excavated by Y.D. Sharma in 1953. Here Harappan and post-Harappan cultures have been traced. The vessels, ornaments, implements, etc., are similar to those of Harappan culture though some new types of pottery, not known in Indus earlier, have also been found.

3.6.8 Banawali

In Hissar district of Haryana, it was excavated by R.S. Bisht in 1974 onwards. Here pre-Harappa, Harappan and post-Harappan cultures have been traced. It was also a well planned town with a difference-streets are radial and houses of mud bricks. The weapons, seals, beads, terracotta figurines, etc., found in large number, are identical to those of the Harappan culture. A complete clay model of a plough, pieces of gold ornaments and black terracotta cult figures have been found here.

3.6.9 Alamgirpur

Twenty miles west of Meerut in Utter Pradesh lies Alamgirpur on the bank of river Hindan, a tributary of Yamuna. The site, excavated in 1958, discovered for the first time the traces of Indus civilization on the Ganga-Yamuna *Doab*. No seal has been found though a number of beads, sherds, terracotta figurines, etc., have been unearthed. Noteworthy are the textile impression on a potsherd and a terracotta bull. This represents the last phase of Harappan culture, i.e., when this culture was in decline.

3.6.10 Alibangan

Situated in Ganganagar district in Rajasthan, the site is known for its pre-Harappan setting. It was explored by A.Ghosh in 1953 and again by B.K. Thapar and B.B Lal in 1961. among the finds, prior to Harappan period, the most important are six types of pottery; blades of chalcedony and agate; bangles of copper, shell and terracotta and terracotta objects like a toy cart and a bull, etc. a ploughed field has been found which is the earliest ploughed field in the world. A fort of Harappan period has also been discovered. It had a citadel, a lower town and some ancillary built up areas which yielded all classical Harappan elements.

3.6.11 Urkotda

It is situated in Kutch district in Gujarat and was excavated by Jagatpati Joshi in 1964. Here a fort has been found. In the last phase of this site bones of horses, hitherto unknown, have been noticed. In cemetery, a special grave covered with a large stone has been excavated.

3.6.12 Lothal

Situated in the village Saragwala in Ahmedabad district in Gujarat, it was discovered by S.R. Rao in 1957. it was a port town and had been divided into three architectural areas-the citadel, the lower town and the dockyard. The citadel had a warehouse, a merchant's house and twelve bathrooms within it. The lower town is divided into straight streets and houses of mud bricks. The most outstanding feature is the dockyard. Constructed of baked bricks, the dockyard is nearly rectangular in shape and 219 x 37 meters in size. This dockyard played a significant role in the trade with West Asia. Stone anvils, bronze drills, crucibles, whole tusks of elephants, copper ingots, a beads factory, etc., have been discovered.

3.6.13 Rangpur

It is 30 miles far off Lothal in Ahmedabad district in Gujarat. It was excavated by M.S. Vats in 1931 and later by S.Ranganath Rao in 1953. remains of late Harappan culture have been noticed. The beads, tools, ornaments, pottery, etc., are similar to the Harappan culture. However, no seal has been found nor any image of mother goddess.

3.6.14 Kunal

The site Kunal in district Hissar, Haryana, has yielded the most unique items of regalia, the first of its kind in Indian sub-continent, consisting of two silver crowns, necklaces of semi-precious stones and gold and silver jewellary, all kept in a pottery jar. Among other notable finds are copper arrow-head and fish hook, beads of carnelian, agate and lapis lazuli and more than twelve thousand beads of semi-precious stones. Seven steatite seals, without any script, prove that the seal manufacturing technique was known to them much before the Harappan used it on vast scale.

3.6.15 Manda

Manda in Jammu represents the northernmost identified site of the Harappan culture. Triangular terracotta cakes of pre-Harappan period and a double-spiral-headed copper pin of West Asian type have been found here.

3.6.16 Dholavira

The ancient ruins at Dholavira, district Kutch (Gujarat), are spread over an area of about 100 hectares, nearly half of which is fortified. The site is remarkable for its exquisite planning, monumental structures, aesthetic architecture and amazing water management system. Besides, it has provided a long succession of rise and fall of first Indian urbanization that is the Harappan civilization. Dholavira now enjoys the unique

distinction of yielding an inscription of ten large-sized signs of Harappan script; indeed the oldest signboard of the world.

3.6.17 Padri

Padri, on the Gulf of Cambay, is in district Bhavnagar, Gujarat. Padri has yielded two cultural horizons: early Harappan and mature Harappan. Interconnected nine-roomed complex belongs to the early Harappan period. Harappan letters on pottery, three unique painted storage jars and copper artifacts are the notable features.

3.6.18 Daimabad

Daimabad in district Ahmednagar, Maharashtra, has yielded four exquisite bronzes comprising an elephant, a rhinoceros, a buffalo and a chariot yoked to a pair of bullocks and driven by a nude human figure. They all together weigh about 65 kg.

3.6.19 Hulas

Hulas, district Saharanpur, Utter Pradesh has provided sturdy red ware of late Harappan tradition. Evidence of cultivated rice and *ragi* is available. Among important finds are terracotta wheels, cakes, beads, and copper objects.

3.7 SURVIVAL & CONTINUITY

There is an organic relationship between the Indus Valley culture and the modern Hinduism- the religion of the former was the lineal progenitor of the latter. There was never a complete break or hiatus after the decline of the Indus Valley culture and though many of its beliefs, conceptions, forms of worship and way of life have disappeared, a large number of them still survive-most of them have gone in the warp and woof of Hinduism. The continuity and the survival of the Harappan culture an be traced in the worship of Shiva, mother goddess, nature(fire, tree, sun, snake), in the belief in evil spirits and in the sacrifice.

Many symbols occurring on the punch-marked coins are reminiscent of the Indus Valley signs. The Harappan people had evolved the system of standard weights and measures which might be responsible for the coinage system of later date.

Thus, in many direct and indirect ways, the Harappan culture kept on influencing the Indian way of life throughout even when the physical traces of this culture vanished or were buried under the earth with the passage of time.

Chapter 4

3-D COMPUTER ANIMATION PIPELINE

The Introduction of 3D computer graphics has had a big impact on the world of animation. Digital characters and sets can now be built and then presented in different media formats such as film, video and interactive games.

The world of 3d computer graphics has grown from experimental short films to full integration into creative process for many types of media. From flying logos to digital actors, the field of 3D computer graphics has evolved rapidly over the last two decades.

What makes 3D such a useful tool is the way it simulates real object .The way objects appear in perspective, the way a surface bends and twists, or the way a light illuminates a space .All these complex 3D effects can now be recreated on the computer.

4.1 THE ANIMATION STAGES

A number of different stages lead up to a final animated 3d sequence, when computers were first used for 3D graphics , these stages were broken into modeling , animating and rendering .These stages have since been expanded with the introduction of character animation , effects and more sophisticated camera and lighting tools.

- Modeling
- Animation
- Characters
- Materials and texturing
- Lights and Cameras
- Effects
- Rendering and compositing

4.2 WORKING IN MAYA 5.0

- Using the interface.
- Creating models. Polygons, NURBS, and subdivision surfaces are different object types with different ways of modeling. Each has its own strengths, and different artists prefer working with different types.
    - Polygons used to model a surface by building up and reshaping a number of simple surface facets.
    - NURBS used to easily create smooth, curving surfaces with high-level control.
    - Subdivision surfaces used to edit surfaces at a high level with minimum overhead data, while still letting us work with subsections of the surface as if they were made from polygons.
- Character rigging. Most animations involve "characters," articulated models such as a person, an animal, robot, or anything else that moves by articulation. Maya defines internal skeletons for characters and bind skin to them to create realistic movement with deformation.
- Animation. Just Maya is "keyable" or able to be animated.
- Dynamics, fluids, and other simulated effects. Maya includes a comprehensive suite of tools for simulating real world effects such as fire, explosions, fluids, hair and fur, the physics of colliding objects, and more.
- Painting and paint effects. Maya includes an incredible system for using a graphics tablet (or the mouse) to paint 2D canvases, paint directly on 3D models, paint to create geometry, scriptable paint, and virtually limitless other possibilities.
- Lighting, Shading, and Rendering. When you want to render a still image or movie of you scene or animation, you can create them using your choice of renderers.

4.3 MODELING

- Polygonal modeling
- Nurbs Modeling
- Sub Division modeling

4.3.1 Polygonal Modeling

A polygon is an n-sided shape, defined by its corners (vertices) and the straight lines between them (edges). When you model with polygons you usually use triangles or quadrilaterals ("quads"), although Maya supports polygons with more sides. An individual polygon is often called a face, and is thought of as the filled area defined by its vertices and edges.

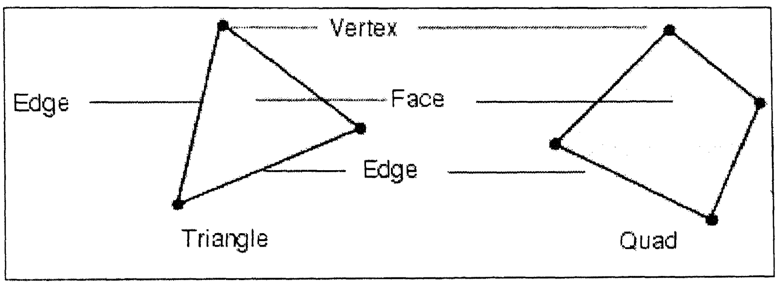


Fig. 4.1

- Polygon Components
- Vertex
- Edge
- Border edge
- Face
- UV

Polygons can share vertices and edges with other polygons. You can use a large number of connected polygons to form shapes. A mesh is a collection of polygons (a mesh is also sometimes called a poly set or a polygonal object). A mesh can contain different types of polygons (triangles, quads, n-sided).

Often a mesh consists only of connected polygons, however it can also be several disjoint sets of connected polygons, called shells.

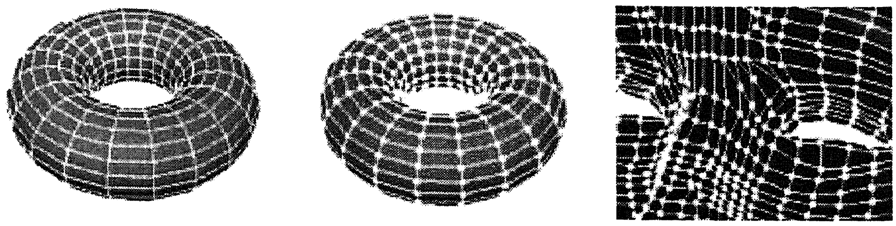


Fig. 4.2

Edges that are not shared (they are on the outside edge of a shell) are called border edges. This Modeling is suitable for Game technology and it uses comparatively less system resources. But achieving smoothness in character animation is difficult and it may increase the polygon count and results in need of powerful computers to process.

4.3.2 Nurbs Modeling

NURBS stands for *Non-Uniform Rational B-Splines.*

- *Non-Uniform* refers to the *parameterization* of the curve. Non-Uniform curves allow, among other things, the presence of multi-knots, which are needed to represent Bezier curves.
- *Rational* refers to the underlying mathematical representation. This property allows NURBS to represent exact conics (such as parabolic curves, circles, and ellipses) in addition to free-form curves.
- *B-splines* are piecewise polynomial curves that have a parametric representation.

  Splines are types of curves, originally developed for ship-building in the days before computer modeling. Naval architects needed a way to draw a smooth curve through a set of points.

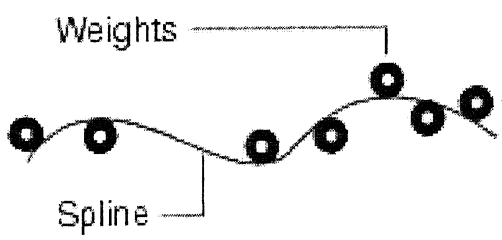


Fig. 4.3

The solution was to place metal weights (called *knots*) at the control points, and bend a thin metal or wooden beam (called a *spline*) through the weights. The physics of the bending spline meant that the influence of each weight was greatest at the point of contact, and decreased smoothly further along the spline. To get more control over a certain region of the spline, the draftsman simply added more weights.

This scheme had obvious problems with data exchange. People needed a mathematical way to describe the shape of the curve. *Cubic Polynomials Splines* are the mathematical equivalent of the draftsman's wooden beam. Polynomials were extended to *B-splines* (for Basis splines), which are sums of lower-level polynomial splines. Then B-splines were extended to create a mathematical representation called NURBS, which are used by Maya.

4.3.3 Subdivision Modeling

Modeling with subdivision surfaces is an easy way to create intricate objects such as human hands. It combines the best features of NURBS and polygonal modeling.

Subdivision surfaces allow you to use a single surface to model complex shapes. A single subdivision surface can have different levels of detail in different regions. That is, a region that has a complex shape can have more control points to allow finer detail, while a simple or flat region needs fewer control points.

4.3.3.1 How it works?

Subdivision surfaces get their name from this dividing into regions of greater detail. You start with a base mesh and divide and subdivide regions into finer and finer detail, with each subdivision giving greater control in that area.

You reshape subdivision surfaces by modifying control points at the different levels of the hierarchy. The base mesh (or "level 0" mesh) allows you to reshape large areas of the overall surface. The subdivided levels allow finer control in specific regions of the surface.

4.3.3.2 Advantages

- Subdivision surfaces allow higher level control over shape than polygons.
- They allow you to only use complex geometry in the complex regions of your model.
- They allow creases (sharp edges) and arbitrary topology (not just four-sided sheets).
- The continuity of subdivision surfaces eliminates many of the problems that can occur at seams when you animate NURBS surfaces.
- You can bind subdivision surfaces to skeletons at a coarse level and the effects will translate smoothly to the finer levels.

4.4 ANIMATION IN MAYA

Types of animation in Maya:

- *Key frame animation* lets you transform objects or skeletons over time by setting key frames. For example, we can key frame the joints and IK handles of a character's arm to create an animation of its arm waving.
- *Driven key animation* lets you link and drive the attributes of one object with those of another object by setting driven keys. For example, we can key a character's X and Z translations as *driver* attributes and a door model's Y rotation as the *driven* attribute to create an animation of a character and a swinging door.
- *Nonlinear animation* lets you split, duplicate, and blend animation clips to achieve the motion effects that you want. For example, we can use nonlinear animation to create a looping walk cycle for one of your characters.
- *Path animation* lets you set a curve as an animation path for an object. When you attach an object to a motion path, it follows the curve during its animation. For example, when we assign a car model to a motion path that follows a road in our scene, the car follows the road when we play the animation.

- *Motion capture animation* lets you use imported motion capture data to apply realistic motion to the characters in your scene. For example, you can use the captured motion of a horse to animate the skeleton of a quadruped model.
- *Dynamic animation* lets you create realistic motion by using the rules of physics to simulate natural forces. For example, you can use dynamics to create effects such as sparks spraying from a welding torch or hail falling from the sky.
- *Expressions* are instructions that you can type to animate attributes. For example, you can write an expression formula that animates the flapping of a birds wings.

4.5 CHARACTER SETUP

Before animating the characters and objects in your scene, you set up your scene by *rigging* all your characters and by applying the appropriate constraints and deformers to all the objects you want to animate.

Rigging a character, also known as *character setup*, involves creating skeletons and IK handles for your characters, binding skins to the skeletons, and setting up deformers and constraints. You can also create deformers for your character and animate them to produce effects; for example, the jiggling belly (jiggle deformer), furrowing brow (wire deformer), and flexing biceps (lattice deformer) of a sumo wrestler model.

Non-character objects are also very important to bringing your scene to life. You can limit and control the transformations of objects by constraining them to characters or other models in your scene. You can also create deformers for objects to create complex deformation effects. For example, you can apply a squash deformer to the model of a ball and then parent constrain the ball to the hands of a character. With this setup, you can key the weights of the character's hands and the squash deformer's attributes to create an animation of the character bouncing the ball from hand to hand while the ball squashes on the ground and stretches as it rises back into the air.

In addition to setting up characters and objects for animation, you can set up dynamics for animation. You can constrain dynamic objects such as particle emitters, fields, and fluids to objects or characters in your scene. For more information, see the *Dynamics* and *Fluid Effects* guides.

The following sections provide a brief overview of the chapters in the *Character Setup* guide:

- Using skeletons
- Skinning your character
- Creating deformation effects
- Constraining objects

4.5.1 Using skeletons

Skeletons are the underlining joint and bone hierarchies that let you animate your characters. Every skeleton has several parent joints and child joints, and one root joint. Parent joints are joints that have joints below them in the skeleton's hierarchy. For example, an elbow is the parent of the wrist and the child of the shoulder. The root joint is the first or top joint in a skeleton's hierarchy
You can use the following methods to animate a skeleton: forward kinematics (FK), inverse kinematics (IK), or IK/FK blending.

4.5.1.1 Forward Kinematics

With forward kinematics, also known as *FK*, you transform and key joints directly, rather than using an IK handle to animate a skeleton.

Forward kinematics are useful for creating detailed arcing movements, but not very intuitive for goal-directed movements. For example, you can easily use FK to animate the rotation of an arm at the shoulder joint, but not the arm reaching for a glass.

4.5.1.2 Inverse Kinematics

With inverse kinematics, also known as *IK*, you transform and key an IK handle to animate a skeleton. The IK handle is drawn as a straight line between the start and end joints of its IK chain. The effect the IK handle has on the joint chain depends on the type of IK solver used by the IK handle. See IK solvers and systems.

Inverse kinematics are useful for goal-directed movements. For example, you can use IK to animate an arm reaching for a glass of water, but not for specific movements at individual joints.

4.5.1.3 Blending IK and FK

Instead of using only FK or IK to pose and animate a joint chain, you can use both FK and IK on the same joint chain. The Ik Blend attribute on the ikHandle lets you apply FK and IK animation to the same joints. Ik Blend specifies the amount of influence (weight) that FK or IK have over the animation of the joints.

Blending IK and FK is useful for posing complex characters that have a wide range of movements in their animations. For example, you can use IK to animate the directed motion of a character's arms, and you can use FK to animate the rotation of the shoulder, elbow, and wrist joints in the arm.

4.5.2 Skinning your character

Skinning is the process of binding a modeled surface to a skeleton. You can bind any model to its skeleton using skinning, or you can model over a pre-existing skeleton to create its skin. When a model is bound to a skeleton using skinning, it then follows or reacts to the transformations of the skeleton's joints and bones. For example, if you bind a model's arm to its underlying skeleton using skinning, rotating the elbow joints causes the skin at the elbow to crease and pucker. There are three types of skinning in Maya: smooth skinning, rigid skinning, and indirect skinning.

4.5.2.1 Smooth Skinning

With smooth skinning, you can create smooth, articulated deformation effects. Smooth skinning specifies that multiple joints and other influence objects can have varying influences on the same points (CVs, vertices, or lattice points) on a model.

4.5.2.2 Rigid Skinning

With rigid skinning, you can create stiff, articulated deformation effects. Rigid skinning specifies that only individual joints can influence each CV, vertex, or lattice point on a model.

4.5.2.3 Indirect skinning

With indirect skinning, you can bind lattice or wrap deformers as skins to a skeleton. When a character is indirectly skinned, posing its skeleton causes the bound deformers to transform the model's skin.

4.5.3 Creating deformation effects

You can add deformation effects to your characters and objects to enhance their animations. Deformers are tools that let you transform or animate objects in ways that simple manipulation and key frames cannot. Deformers have two main applications: to model surfaces or to add extra shape animations to an object.

4.5.3.1 Deformers as modeling tools

You can use deformers as modeling tools. You can create a deformer, for example a sculpt deformer tool, tweak the model's shape with it, and then delete the history from your object when the deformer is no longer needed. When you delete the object's history, you delete the deformer and retain the object's deformed shape.

4.5.4.2 Orient constraints

Orient constraints limit and control only the rotation channels of the constrained object. Orient constraints are useful when you want to constrain the orientation of one object to that of another. For example, you can use an orient constraint to constrain the blades of one windmill to those of another. In this example, when the target windmill's blades turn around their axis, the constrained windmill's blades rotate around their own local axis.

4.5.4.3 Parent constraints

Parent constraints cause the constrained object to inherit the transformations and global orientation of its target objects, mimicking a parent-child relationship. For example, you can constrain the model of a hat to the head and hands of a character with a parent constraint, so that when the head nods and rotates side to side, the hat follows the head's movements. And when the hand grabs the hat and lifts it off the head, the hat follows the hand. In this example, setting and keying the target weights lets you anchor in time the amount of influence the head and hands have on the hat.

4.5.4.4 Scale constraints

Scale constraints limit and control the scaling channels of the constrained object. Scale constraints are useful when you want the size of one object to drive that of another object. For example, you can constrain the models of blades of grass to each other, so that when they appear to grow during their animation, the size of each blade of grass increases by the same amount.

4.5.4.5 Aim constraints

Aim constraints limit and control the rotation channels and aim vector of the constrained object. The aim vector is an attribute on the aim constraint that forces the constrained object to always point at the target objects. Aim constraints are useful when you want the

constrained object to always follow and point at the target objects. For example, you can constrain the eyes of a character to track the movements of another character in your scene.

4.5.4.6 Geometry constraints

Geometry constraints constrain or bind the constrained object so that it follows the target curve or surface as it changes shape. Geometry constraints are useful when you want to attach one object to the surface of another without using more complex methods such as MEL or expressions. For example, you can bind a virus model to the surface of a cell model with a geometry constraint.

4.5.4.7 Normal constraints

Normal constraints limit and control the orientation of the constrained object so that it aligns with the normal vectors of the target object's surface. Normal constraints are useful when you want an object to travel across a surface. Typically, you use normal constraints in conjunction with geometry constraints. For example, you can use a normal constraint and a geometry constraint to properly constrain a button on to a shirt.

4.5.4.8 Tangent constraints

Tangent constraints limit and control the orientation of the constrained object so that the constrained object is forced to point in the direction of the tangent at its current location (point) on the curve. Typically, you use tangent constraints in conjunction with geometry constraints. For example, you can use a tangent and a geometry constraint to attach the model of a roller coaster car to roller coaster tracks. During the animation, the car follows the shape and tangents of the track.

4.5.4.9 Pole Vector constraints

Pole Vector constraints cause the ends of pole vectors to move to and follow the position of an object, or the average position of several objects. The pole vector is a component of

the IK rotate plane handle that determines where you get flipping when the IK handle crosses the pole vector. Pole Vector constraints are useful because they let you control flipping and the position of joints (for example, the elbow) in an IK joint chain.

4.6 ANIMATION-CONSTRAINT BLENDS

You can apply animation and constraints to the same object. When you key frame a constrained object or assign a constraint to a key framed object, a pair Blend attribute is automatically added to the object. You can set and key the pair Blend attribute to animate the animation-constraint blend weight. The blend weight determines the amount of influence the animation and constraints have on the constrained object. For example, you can constrain a ball to the hands of two characters and key the hand weights. When the ball is thrown from one character to another, you can then keyframe the ball's flight through the air. The process of applying animation and constraints to the same object and then keying the blend weight is called animation-constraint blending.

4.7 CHARACTER SETS

Character sets let you group attributes from multiple objects into a single node that you can then select and key. Character sets are useful when you want to animate multiple attributes from many different objects all at the same time. For example, we can use a character set to bring together in one node all the joint rotations of a character's legs.

4.8 SURFACE SHADING

In the real world, what an object is made of is one of two main factors that determine the appearance of its surface (the other is light). This is because when light hits the objects, some of the light is absorbed and some of it is reflected. The smoother the object, the shiny. In Maya, the appearance of a surface is defined by how it's *shaded.* Surface shading is a combination of the basic material of an object and any textures that are applied to it.

In Maya, *materials* (also called *shaders*) define an object's substance. Some of the most basic attributes of materials include color, transparency, and shine, though materials have many more adjustable attributes.

Factors beyond basic color, transparency, and shine that determine the appearance of an object's surface include:

- more complex combinations of color, transparency, and shine
- whether or not the surface has any surface relief
- whether or not the surface casts or catches reflections.

A *shading network* is a collection of connected rendering nodes that defines how colors and textures contribute (usually with lights) to the final look of surfaces (materials). A shading network typically consists of any number of connected rendering nodes plugged into a shading group node.

A good portion of your time building shading networks is spent connecting node attributes to each other and adjusting node attributes to describe what a surface should look like and how it should be positioned.

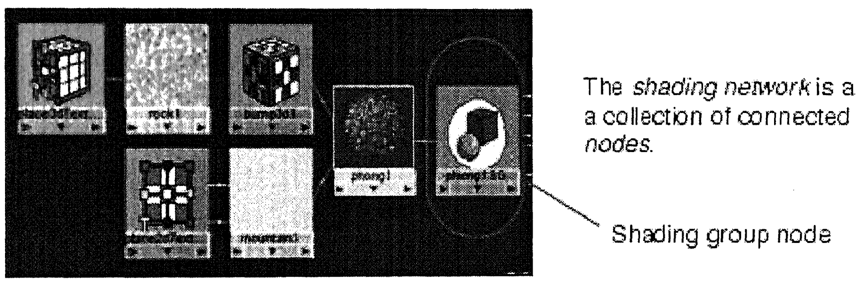


Fig 4.4

Shading networks are designed as a data flow network, where data streams from the left side of the network toward a final shaded result that emerges from the right node. The right most node, which is not always visible by default, is the shading group for that particular network.

The shading group is a collection of materials, textures, and lights that efficiently describe all the necessary attributes required to shade or render an image affect the final render of the surface.

All of the nodes connected upstream (Figs 4.4) of the shading group contribute to the final look of surfaces in the scene. Adjusting any node's attributes or connections causes a downstream (Figs 4.4) reaction that can be seen in the final rendered image.

4.9 LIGHT AND CAMERAS

Planning Light Source

Character or object illumination typically includes the following lights.

- A *key light* is the main light that illuminates the character or object. For outdoor scenes in the real world, the key light is generally the sun.
- A *secondary light*, often called a fill light because it fills in dark areas.
- *Backlights*, if necessary, to distinguish the character or object from the background.

4.9.1 The characteristics of light sources

Consider the following characteristics of light source when planning your scenes.

4.9.1.1 Softness or hardness

Hard light produces sharp shadow lines. Hard light sources typically include light bulbs, bright sun, and flash lights.

Soft light is diffused and produces soft edges. Soft light sources typically include light shining through fabric (like drapes), reflected light, or sunlight diffused through clouds.

4.9.1.2 Color

Color and temperature are closely related. A red spot light shining on a blue object may make it look black. Some common objects, like street lamps may be tinted yellow.

4.9.1.3 Temperature

Soft orange light feels warmer than blue-green light.

4.9.1.4 Intensity

The intensity of a light source is how bright it is. For example, bright high-noon sunlight usually is more intense than a small electronic LED. The intensity with which a light illuminates a subject appears to lessen (or decay) as the subject moves farther away from the light.

4.9.1.5 Movement

Lighthouse lights rotate. Flashlights might swing from a rope.

4.10 SHADOW IN MAYA

Shadows work with lights to add realism to your scenes. Shadows help to define the location of objects, whether they rest on the ground or hover in space, for example. Shadows can be soft-edged or hard-edged, and their presence (or absence) can be used to add balance and contrast to objects in your scene.

To create a shadow, a scene must contain a shadow-casting light, a shadow-casting surface, and a shadow-catching surface. The light must illuminate both the shadow-casting surface and the shadow-catching surface.

Depth Map Shadows

- Two types of shadows

A depth map represents the distance from a specific light to the surfaces the light illuminates. A depth map is an data file that contains the depth data rendered from a light's point of view. Each pixel in the depth map represents the distance from the light to the nearest shadow casting surface in a specific direction. Depth map shadows produce very good results in almost all situations, with marginal increase to rendering time.

- Ray tracing

Ray traced shadows only to produce more physically accurate shadows (like those in the real world). Common purposes include:

- (for area lights only) where shadows blur and become lighter as they increase in distance from the object
- to produce shadows from transparent colored surfaces
- to produce soft-edged shadows (though depth maps can also produce good results)

4.11 MAYA CAMERAS

Maya cameras have certain advantages over real world cameras, giving you more creative freedom. For example, because Maya cameras are not constrained by size or weight, you can move cameras to *any* position in your scene, even inside the smallest objects.

Types of cameras

Three types of cameras help you create both static and animated scenes.

- Basic camera for static scenes and for simple animations (up, down, side to side, in and out), such as panning out of a scene.
- Camera and Aim camera for slightly more complex animations (along a path, for example), such as a camera that follows the erratic path of a bird.
- Camera, Aim, and Up camera to specify which end of the camera must face upward. This camera is best for complex animations, such as a camera that travels along a looping roller coaster.

4.12 RENDERING

Rendering is the final stage in the 3D computer graphics production process. As you shade objects, light your scene, and set up cameras, you test iterations of your scene to see the results of your adjustments. When you have finished creating your scene, you must render your scene to produce the final images.

Though the wider context of rendering includes shading and texturing objects (see the *Shading* guide for more information), lighting scenes and setting cameras (see the *Lights and Cameras* guide for more information), the final process of rendering is the stage in which surfaces, materials, lights, and motion are processed into images.

The art of rendering is finding a balance between the visual complexity required and the rendering speed that determines how many frames can be rendered in a given period of time.

The science of rendering involves a large number of complex calculations, which can keep your computer busy for a long time. Rendering pulls data together from every sub-system within Maya: interpreting modeling construction histories, IK chains, stacked deformations, rigid body, soft body, particle dynamics, and more. At the same time, rendering interprets its own data relevant to tessellation, texture mapping, shading, clipping, and lighting.

The key is to produce good enough quality images in as little time as possible in order to meet production deadlines. The choices you make to render your scene always involve a trade-off between quality and speed.

Chapter 4

3-D COMPUTER ANIMATION PIPELINE

The Introduction of 3D computer graphics has had a big impact on the world of animation. Digital characters and sets can now be built and then presented in different media formats such as film, video and interactive games.

The world of 3d computer graphics has grown from experimental short films to full integration into creative process for many types of media. From flying logos to digital actors, the field of 3D computer graphics has evolved rapidly over the last two decades.

What makes 3D such a useful tool is the way it simulates real object .The way objects appear in perspective, the way a surface bends and twists, or the way a light illuminates a space .All these complex 3D effects can now be recreated on the computer.

4.1 THE ANIMATION STAGES

A number of different stages lead up to a final animated 3d sequence, when computers were first used for 3D graphics , these stages were broken into modeling , animating and rendering .These stages have since been expanded with the introduction of character animation , effects and more sophisticated camera and lighting tools.

- Modeling
- Animation
- Characters
- Materials and texturing
- Lights and Cameras
- Effects
- Rendering and compositing

4.2 WORKING IN MAYA 5.0

- Using the interface.
- Creating models. Polygons, NURBS, and subdivision surfaces are different object types with different ways of modeling. Each has its own strengths, and different artists prefer working with different types.
    - Polygons used to model a surface by building up and reshaping a number of simple surface facets.
    - NURBS used to easily create smooth, curving surfaces with high-level control.
    - Subdivision surfaces used to edit surfaces at a high level with minimum overhead data, while still letting us work with subsections of the surface as if they were made from polygons.
- Character rigging. Most animations involve "characters," articulated models such as a person, an animal, robot, or anything else that moves by articulation. Maya defines internal skeletons for characters and bind skin to them to create realistic movement with deformation.
- Animation. Just Maya is "keyable" or able to be animated.
- Dynamics, fluids, and other simulated effects. Maya includes a comprehensive suite of tools for simulating real world effects such as fire, explosions, fluids, hair and fur, the physics of colliding objects, and more.
- Painting and paint effects. Maya includes an incredible system for using a graphics tablet (or the mouse) to paint 2D canvases, paint directly on 3D models, paint to create geometry, scriptable paint, and virtually limitless other possibilities.
- Lighting, Shading, and Rendering. When you want to render a still image or movie of you scene or animation, you can create them using your choice of renderers.

4.3 MODELING

- Polygonal modeling
- Nurbs Modeling
- Sub Division modeling

4.3.1 Polygonal Modeling

A polygon is an n-sided shape, defined by its corners (vertices) and the straight lines between them (edges). When you model with polygons you usually use triangles or quadrilaterals ("quads"), although Maya supports polygons with more sides. An individual polygon is often called a face, and is thought of as the filled area defined by its vertices and edges.

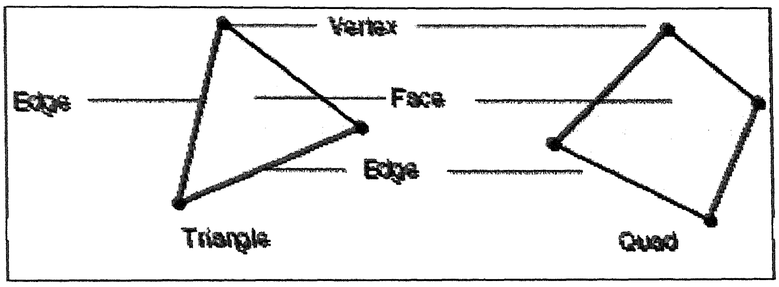


Fig. 4.1

- Polygon Components
- Vertex
- Edge
- Border edge
- Face
- UV

Polygons can share vertices and edges with other polygons. You can use a large number of connected polygons to form shapes. A mesh is a collection of polygons (a mesh is also sometimes called a poly set or a polygonal object). A mesh can contain different types of polygons (triangles, quads, n-sided).

Often a mesh consists only of connected polygons, however it can also be several disjoint sets of connected polygons, called shells.

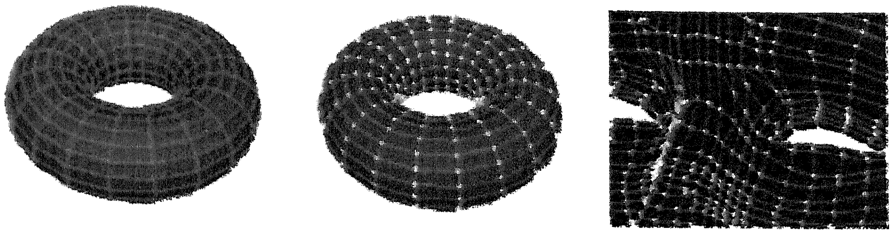


Fig. 4.2

Edges that are not shared (they are on the outside edge of a shell) are called border edges. This Modeling is suitable for Game technology and it uses comparatively less system resources. But achieving smoothness in character animation is difficult and it may increase the polygon count and results in need of powerful computers to process.

4.3.2 Nurbs Modeling

NURBS stands for *Non-Uniform Rational B-Splines.*

- *Non-Uniform* refers to the *parameterization* of the curve. Non-Uniform curves allow, among other things, the presence of multi-knots, which are needed to represent Bezier curves.
- *Rational* refers to the underlying mathematical representation. This property allows NURBS to represent exact conics (such as parabolic curves, circles, and ellipses) in addition to free-form curves.
- *B-splines* are piecewise polynomial curves that have a parametric representation.

  Splines are types of curves, originally developed for ship-building in the days before computer modeling. Naval architects needed a way to draw a smooth curve through a set of points.

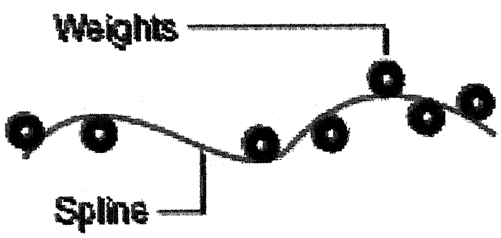


Fig. 4.3

The solution was to place metal weights (called *knots*) at the control points, and bend a thin metal or wooden beam (called a *spline*) through the weights. The physics of the bending spline meant that the influence of each weight was greatest at the point of contact, and decreased smoothly further along the spline. To get more control over a certain region of the spline, the draftsman simply added more weights.

This scheme had obvious problems with data exchange. People needed a mathematical way to describe the shape of the curve. *Cubic Polynomials Splines* are the mathematical equivalent of the draftsman's wooden beam. Polynomials were extended to *B-splines* (for Basis splines), which are sums of lower-level polynomial splines. Then B-splines were extended to create a mathematical representation called NURBS, which are used by Maya.

4.3.3 Subdivision Modeling

Modeling with subdivision surfaces is an easy way to create intricate objects such as human hands. It combines the best features of NURBS and polygonal modeling.

Subdivision surfaces allow you to use a single surface to model complex shapes. A single subdivision surface can have different levels of detail in different regions. That is, a region that has a complex shape can have more control points to allow finer detail, while a simple or flat region needs fewer control points.

4.3.3.1 How it works?

Subdivision surfaces get their name from this dividing into regions of greater detail. You start with a base mesh and divide and subdivide regions into finer and finer detail, with each subdivision giving greater control in that area.

You reshape subdivision surfaces by modifying control points at the different levels of the hierarchy. The base mesh (or "level 0" mesh) allows you to reshape large areas of the overall surface. The subdivided levels allow finer control in specific regions of the surface.

4.3.3.2 Advantages

- Subdivision surfaces allow higher level control over shape than polygons.
- They allow you to only use complex geometry in the complex regions of your model.
- They allow creases (sharp edges) and arbitrary topology (not just four-sided sheets).
- The continuity of subdivision surfaces eliminates many of the problems that can occur at seams when you animate NURBS surfaces.
- You can bind subdivision surfaces to skeletons at a coarse level and the effects will translate smoothly to the finer levels.

4.4 ANIMATION IN MAYA

Types of animation in Maya:

- *Key frame animation* lets you transform objects or skeletons over time by setting key frames. For example, we can key frame the joints and IK handles of a character's arm to create an animation of its arm waving.
- *Driven key animation* lets you link and drive the attributes of one object with those of another object by setting driven keys. For example, we can key a character's X and Z translations as *driver* attributes and a door model's Y rotation as the *driven* attribute to create an animation of a character and a swinging door.
- *Nonlinear animation* lets you split, duplicate, and blend animation clips to achieve the motion effects that you want. For example, we can use nonlinear animation to create a looping walk cycle for one of your characters.
- *Path animation* lets you set a curve as an animation path for an object. When you attach an object to a motion path, it follows the curve during its animation. For example, when we assign a car model to a motion path that follows a road in our scene, the car follows the road when we play the animation.

- *Motion capture animation* lets you use imported motion capture data to apply realistic motion to the characters in your scene. For example, you can use the captured motion of a horse to animate the skeleton of a quadruped model.
- *Dynamic animation* lets you create realistic motion by using the rules of physics to simulate natural forces. For example, you can use dynamics to create effects such as sparks spraying from a welding torch or hail falling from the sky.
- *Expressions* are instructions that you can type to animate attributes. For example, you can write an expression formula that animates the flapping of a birds wings.

4.5 CHARACTER SETUP

Before animating the characters and objects in your scene, you set up your scene by *rigging* all your characters and by applying the appropriate constraints and deformers to all the objects you want to animate.

Rigging a character, also known as *character setup*, involves creating skeletons and IK handles for your characters, binding skins to the skeletons, and setting up deformers and constraints. You can also create deformers for your character and animate them to produce effects; for example, the jiggling belly (jiggle deformer), furrowing brow (wire deformer), and flexing biceps (lattice deformer) of a sumo wrestler model.

Non-character objects are also very important to bringing your scene to life. You can limit and control the transformations of objects by constraining them to characters or other models in your scene. You can also create deformers for objects to create complex deformation effects. For example, you can apply a squash deformer to the model of a ball and then parent constrain the ball to the hands of a character. With this setup, you can key the weights of the character's hands and the squash deformer's attributes to create an animation of the character bouncing the ball from hand to hand while the ball squashes on the ground and stretches as it rises back into the air.

In addition to setting up characters and objects for animation, you can set up dynamics for animation. You can constrain dynamic objects such as particle emitters, fields, and fluids to objects or characters in your scene. For more information, see the *Dynamics* and *Fluid Effects* guides.

The following sections provide a brief overview of the chapters in the *Character Setup* guide:

- Using skeletons
- Skinning your character
- Creating deformation effects
- Constraining objects

4.5.1 Using skeletons

Skeletons are the underlining joint and bone hierarchies that let you animate your characters. Every skeleton has several parent joints and child joints, and one root joint. Parent joints are joints that have joints below them in the skeleton's hierarchy. For example, an elbow is the parent of the wrist and the child of the shoulder. The root joint is the first or top joint in a skeleton's hierarchy

You can use the following methods to animate a skeleton: forward kinematics (FK), inverse kinematics (IK), or IK/FK blending.

4.5.1.1 Forward Kinematics

With forward kinematics, also known as *FK*, you transform and key joints directly, rather than using an IK handle to animate a skeleton.

Forward kinematics are useful for creating detailed arcing movements, but not very intuitive for goal-directed movements. For example, you can easily use FK to animate the rotation of an arm at the shoulder joint, but not the arm reaching for a glass.

4.5.1.2 Inverse Kinematics

With inverse kinematics, also known as *IK*, you transform and key an IK handle to animate a skeleton. The IK handle is drawn as a straight line between the start and end joints of its IK chain. The effect the IK handle has on the joint chain depends on the type of IK solver used by the IK handle. See IK solvers and systems.

Inverse kinematics are useful for goal-directed movements. For example, you can use IK to animate an arm reaching for a glass of water, but not for specific movements at individual joints.

4.5.1.3 Blending IK and FK

Instead of using only FK or IK to pose and animate a joint chain, you can use both FK and IK on the same joint chain. The Ik Blend attribute on the ikHandle lets you apply FK and IK animation to the same joints. Ik Blend specifies the amount of influence (weight) that FK or IK have over the animation of the joints.

Blending IK and FK is useful for posing complex characters that have a wide range of movements in their animations. For example, you can use IK to animate the directed motion of a character's arms, and you can use FK to animate the rotation of the shoulder, elbow, and wrist joints in the arm.

4.5.2 Skinning your character

Skinning is the process of binding a modeled surface to a skeleton. You can bind any model to its skeleton using skinning, or you can model over a pre-existing skeleton to create its skin. When a model is bound to a skeleton using skinning, it then follows or reacts to the transformations of the skeleton's joints and bones. For example, if you bind a model's arm to its underlying skeleton using skinning, rotating the elbow joints causes the skin at the elbow to crease and pucker. There are three types of skinning in Maya: smooth skinning, rigid skinning, and indirect skinning.

4.5.2.1 Smooth Skinning

With smooth skinning, you can create smooth, articulated deformation effects. Smooth skinning specifies that multiple joints and other influence objects can have varying influences on the same points (CVs, vertices, or lattice points) on a model.

4.5.2.2 Rigid Skinning

With rigid skinning, you can create stiff, articulated deformation effects. Rigid skinning specifies that only individual joints can influence each CV, vertex, or lattice point on a model.

4.5.2.3 Indirect skinning

With indirect skinning, you can bind lattice or wrap deformers as skins to a skeleton. When a character is indirectly skinned, posing its skeleton causes the bound deformers to transform the model's skin.

4.5.3 Creating deformation effects

You can add deformation effects to your characters and objects to enhance their animations. Deformers are tools that let you transform or animate objects in ways that simple manipulation and key frames cannot. Deformers have two main applications: to model surfaces or to add extra shape animations to an object.

4.5.3.1 Deformers as modeling tools

You can use deformers as modeling tools. You can create a deformer, for example a sculpt deformer tool, tweak the model's shape with it, and then delete the history from your object when the deformer is no longer needed. When you delete the object's history, you delete the deformer and retain the object's deformed shape.

4.5.3.2 Deformers as animation tools

You can use deformers as animation tools. You can create a deformer, tweak the target object with the deformer, and then key the deformer's attributes over time to produce an animation. For example, you can create a blend shape deformer for a model of a face. Then over time, you can manipulate and key the sliders for the deformer in the Blend Shape editor to create an animation.

4.5.4 Constraining objects

With constraints, you can drive the position, orientation, and scale of one object with the transformation settings of another object. The object that is driven is called the *constrained* object, and the driver object is called the *target* object. The specific channels that are driven by a constraint depends on the type of constraint. For example, for an object constrained by a point constraint, only its X, Y, and/or Z translations are driven by its target objects. When a constraint relationship has more than one target object, *weights* are used to determine the amount of influence each object has on the constrained object.

The following constraint types are available: point, orient, scale, aim, parent, geometry, tangent, and pole vector.

4.5.4.1 Point constraints

Point constraints limit and control only the translation channels of the constrained object. Point constraints are useful when you want to constrain the position of one object to that of another without parenting. For example, you can use a point constraint to constrain the model of a crate to an animated train model and to the model of a crane that lifts the crate on and off the train. In this example, you can key the targets (the train and the crane) weights to determine which model at what time in the animation controls the translation of the crate.

4.5.4.2 Orient constraints

Orient constraints limit and control only the rotation channels of the constrained object. Orient constraints are useful when you want to constrain the orientation of one object to that of another. For example, you can use an orient constraint to constrain the blades of one windmill to those of another. In this example, when the target windmill's blades turn around their axis, the constrained windmill's blades rotate around their own local axis.

4.5.4.3 Parent constraints

Parent constraints cause the constrained object to inherit the transformations and global orientation of its target objects, mimicking a parent-child relationship. For example, you can constrain the model of a hat to the head and hands of a character with a parent constraint, so that when the head nods and rotates side to side, the hat follows the head's movements. And when the hand grabs the hat and lifts it off the head, the hat follows the hand. In this example, setting and keying the target weights lets you anchor in time the amount of influence the head and hands have on the hat.

4.5.4.4 Scale constraints

Scale constraints limit and control the scaling channels of the constrained object. Scale constraints are useful when you want the size of one object to drive that of another object. For example, you can constrain the models of blades of grass to each other, so that when they appear to grow during their animation, the size of each blade of grass increases by the same amount.

4.5.4.5 Aim constraints

Aim constraints limit and control the rotation channels and aim vector of the constrained object. The aim vector is an attribute on the aim constraint that forces the constrained object to always point at the target objects. Aim constraints are useful when you want the

constrained object to always follow and point at the target objects. For example, you can constrain the eyes of a character to track the movements of another character in your scene.

4.5.4.6 Geometry constraints

Geometry constraints constrain or bind the constrained object so that it follows the target curve or surface as it changes shape. Geometry constraints are useful when you want to attach one object to the surface of another without using more complex methods such as MEL or expressions. For example, you can bind a virus model to the surface of a cell model with a geometry constraint.

4.5.4.7 Normal constraints

Normal constraints limit and control the orientation of the constrained object so that it aligns with the normal vectors of the target object's surface. Normal constraints are useful when you want an object to travel across a surface. Typically, you use normal constraints in conjunction with geometry constraints. For example, you can use a normal constraint and a geometry constraint to properly constrain a button on to a shirt.

4.5.4.8 Tangent constraints

Tangent constraints limit and control the orientation of the constrained object so that the constrained object is forced to point in the direction of the tangent at its current location (point) on the curve. Typically, you use tangent constraints in conjunction with geometry constraints. For example, you can use a tangent and a geometry constraint to attach the model of a roller coaster car to roller coaster tracks. During the animation, the car follows the shape and tangents of the track.

4.5.4.9 Pole Vector constraints

Pole Vector constraints cause the ends of pole vectors to move to and follow the position of an object, or the average position of several objects. The pole vector is a component of

the IK rotate plane handle that determines where you get flipping when the IK handle crosses the pole vector. Pole Vector constraints are useful because they let you control flipping and the position of joints (for example, the elbow) in an IK joint chain.

4.6 ANIMATION-CONSTRAINT BLENDS

You can apply animation and constraints to the same object. When you key frame a constrained object or assign a constraint to a key framed object, a pair Blend attribute is automatically added to the object. You can set and key the pair Blend attribute to animate the animation-constraint blend weight. The blend weight determines the amount of influence the animation and constraints have on the constrained object. For example, you can constrain a ball to the hands of two characters and key the hand weights. When the ball is thrown from one character to another, you can then keyframe the ball's flight through the air. The process of applying animation and constraints to the same object and then keying the blend weight is called animation-constraint blending.

4.7 CHARACTER SETS

Character sets let you group attributes from multiple objects into a single node that you can then select and key. Character sets are useful when you want to animate multiple attributes from many different objects all at the same time. For example, we can use a character set to bring together in one node all the joint rotations of a character's legs.

4.8 SURFACE SHADING

In the real world, what an object is made of is one of two main factors that determine the appearance of its surface (the other is light). This is because when light hits the objects, some of the light is absorbed and some of it is reflected. The smoother the object, the shiny. In Maya, the appearance of a surface is defined by how it's *shaded*. Surface shading is a combination of the basic material of an object and any textures that are applied to it.

In Maya, *materials* (also called *shaders*) define an object's substance. Some of the most basic attributes of materials include color, transparency, and shine, though materials have many more adjustable attributes.

Factors beyond basic color, transparency, and shine that determine the appearance of an object's surface include:

- more complex combinations of color, transparency, and shine
- whether or not the surface has any surface relief
- whether or not the surface casts or catches reflections.

A *shading network* is a collection of connected rendering nodes that defines how colors and textures contribute (usually with lights) to the final look of surfaces (materials). A shading network typically consists of any number of connected rendering nodes plugged into a shading group node.

A good portion of your time building shading networks is spent connecting node attributes to each other and adjusting node attributes to describe what a surface should look like and how it should be positioned.

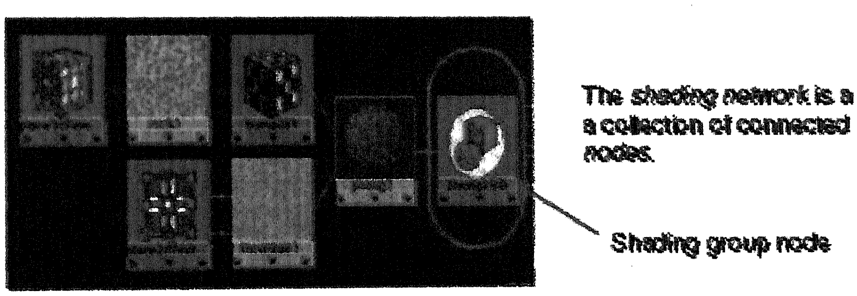


Fig 4.4

Shading networks are designed as a data flow network, where data streams from the left side of the network toward a final shaded result that emerges from the right node. The right most node, which is not always visible by default, is the shading group for that particular network.

The shading group is a collection of materials, textures, and lights that efficiently describe all the necessary attributes required to shade or render an image affect the final render of the surface.

All of the nodes connected upstream (Figs 4.4) of the shading group contribute to the final look of surfaces in the scene. Adjusting any node's attributes or connections causes a downstream (Figs 4.4) reaction that can be seen in the final rendered image.

4.9 LIGHT AND CAMERAS

Planning Light Source

Character or object illumination typically includes the following lights.

- A *key light* is the main light that illuminates the character or object. For outdoor scenes in the real world, the key light is generally the sun.
- A *secondary light*, often called a fill light because it fills in dark areas.
- *Backlights*, if necessary, to distinguish the character or object from the background.

4.9.1 The characteristics of light sources

Consider the following characteristics of light source when planning your scenes.

4.9.1.1 Softness or hardness

Hard light produces sharp shadow lines. Hard light sources typically include light bulbs, bright sun, and flash lights.

Soft light is diffused and produces soft edges. Soft light sources typically include light shining through fabric (like drapes), reflected light, or sunlight diffused through clouds.

4.9.1.2 Color

Color and temperature are closely related. A red spot light shining on a blue object may make it look black. Some common objects, like street lamps may be tinted yellow.

4.9.1.3 Temperature

Soft orange light feels warmer than blue-green light.

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The intensity of a light source is how bright it is. For example, bright high-noon sunlight usually is more intense than a small electronic LED. The intensity with which a light illuminates a subject appears to lessen (or decay) as the subject moves farther away from the light.

4.9.1.5 Movement

Lighthouse lights rotate. Flashlights might swing from a rope.

4.10 SHADOW IN MAYA

Shadows work with lights to add realism to your scenes. Shadows help to define the location of objects, whether they rest on the ground or hover in space, for example. Shadows can be soft-edged or hard-edged, and their presence (or absence) can be used to add balance and contrast to objects in your scene.

To create a shadow, a scene must contain a shadow-casting light, a shadow-casting surface, and a shadow-catching surface. The light must illuminate both the shadow-casting surface and the shadow-catching surface.

Depth Map Shadows

- Two types of shadows

A depth map represents the distance from a specific light to the surfaces the light illuminates. A depth map is an data file that contains the depth data rendered from a light's point of view. Each pixel in the depth map represents the distance from the light to the nearest shadow casting surface in a specific direction. Depth map shadows produce very good results in almost all situations, with marginal increase to rendering time.

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The key is to produce good enough quality images in as little time as possible in order to meet production deadlines. The choices you make to render your scene always involve a trade-off between quality and speed.

Chapter 5

MULTIMEDIA CONTENT CREATION OF INDUS

5.1 DIGITAL RESTORATION OF MOHENJO –DARO CITY.

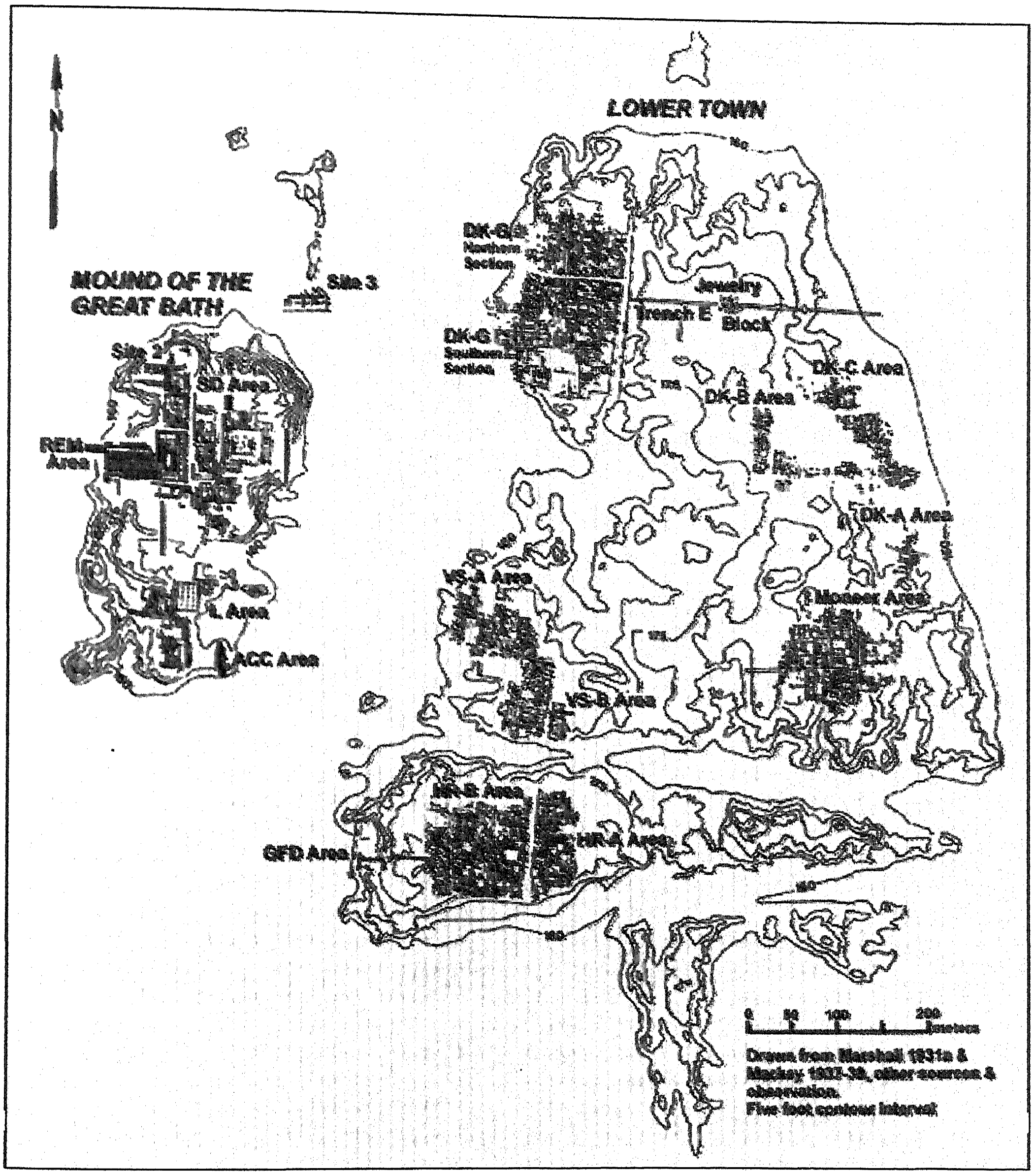

Fig. 5.1: Plan of mohenjo-daro

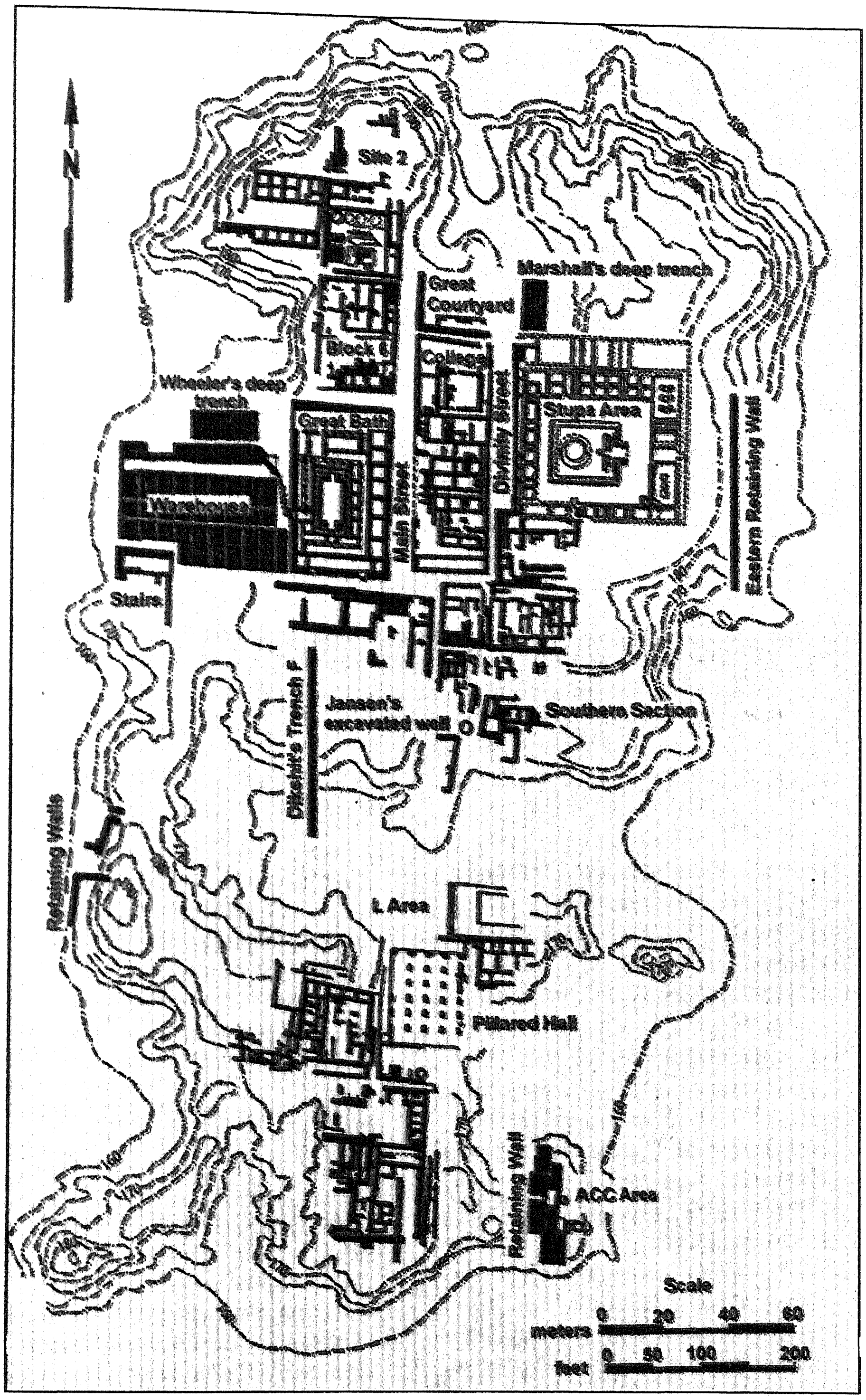

Fig. 5.2: Plan of Citadel Area

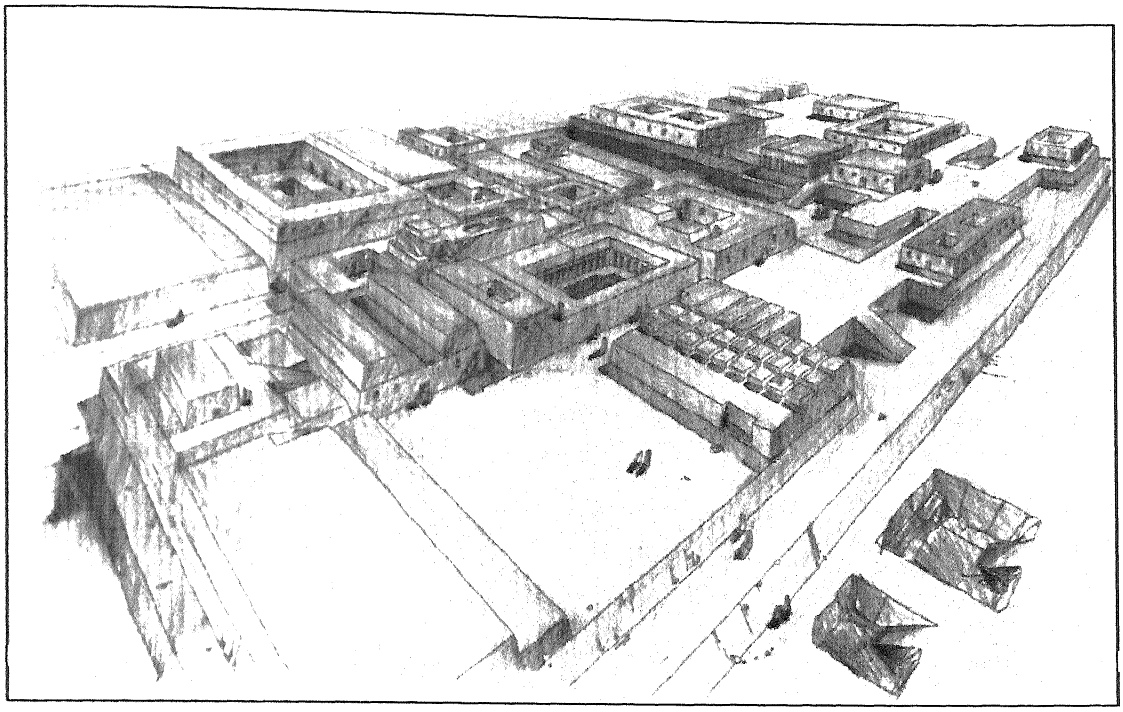

Fig. 5.3: Sketch of Citadel area

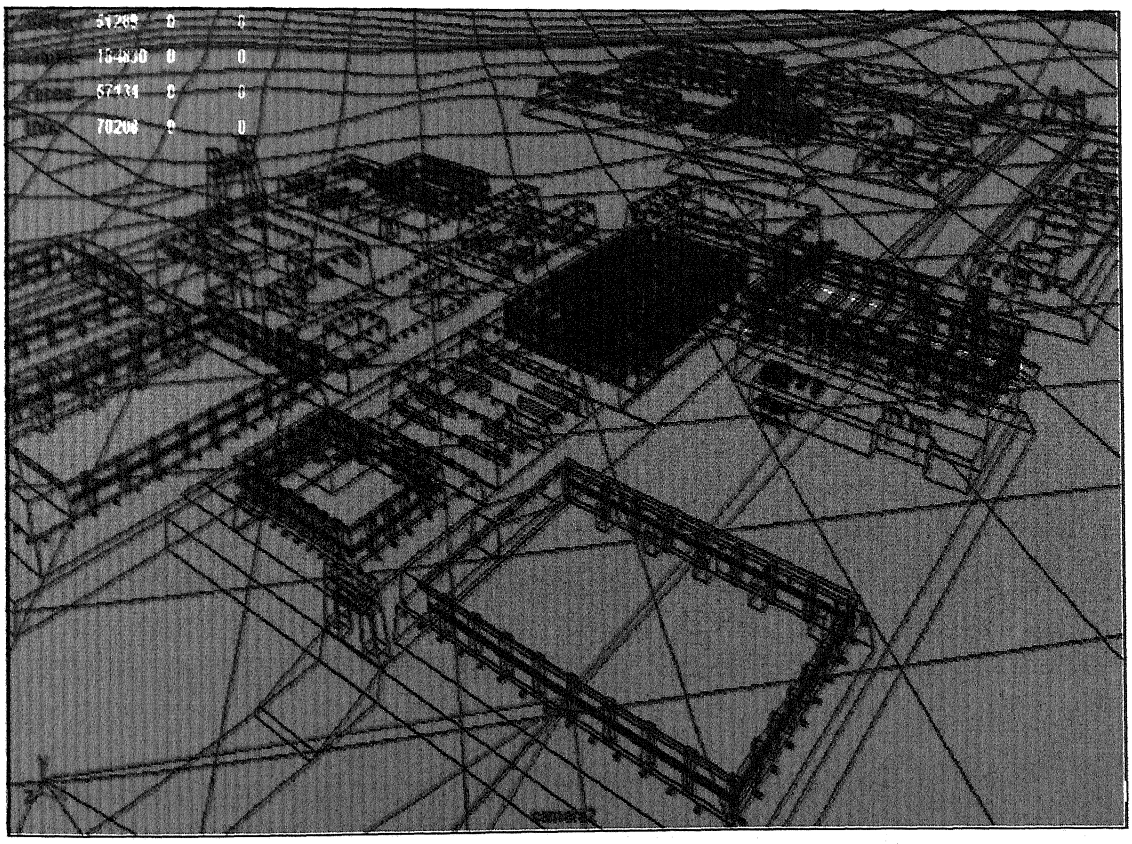

Fig. 5.4: Citadel restoration – Wire Frame Model

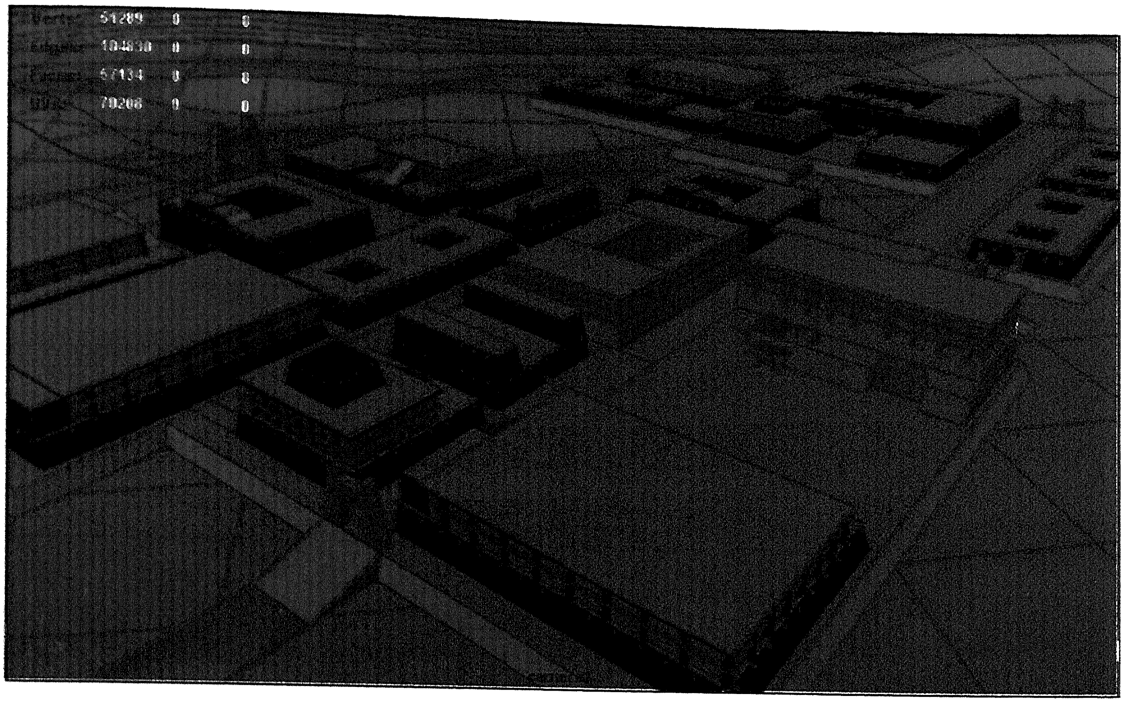

Fig. 5.5: Citadel restoration – Shaded mode

Fig. 5.6: Citadel restoration – textured and lighting applied

Fig. 5.7: Citadel restoration –Environmental fog applied

5.2 DIGITAL RESTORATION OF GREAT BATH

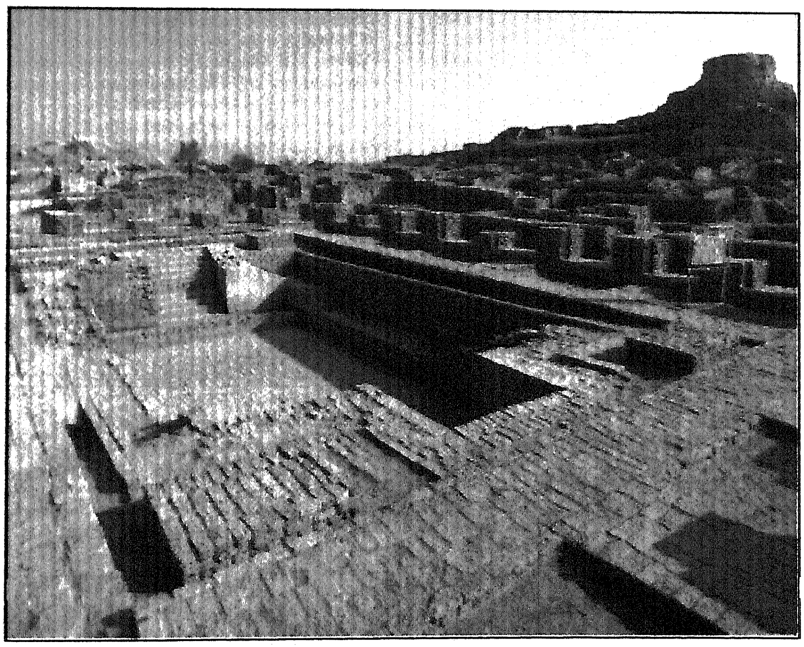

Fig. 5.8: Great Bath

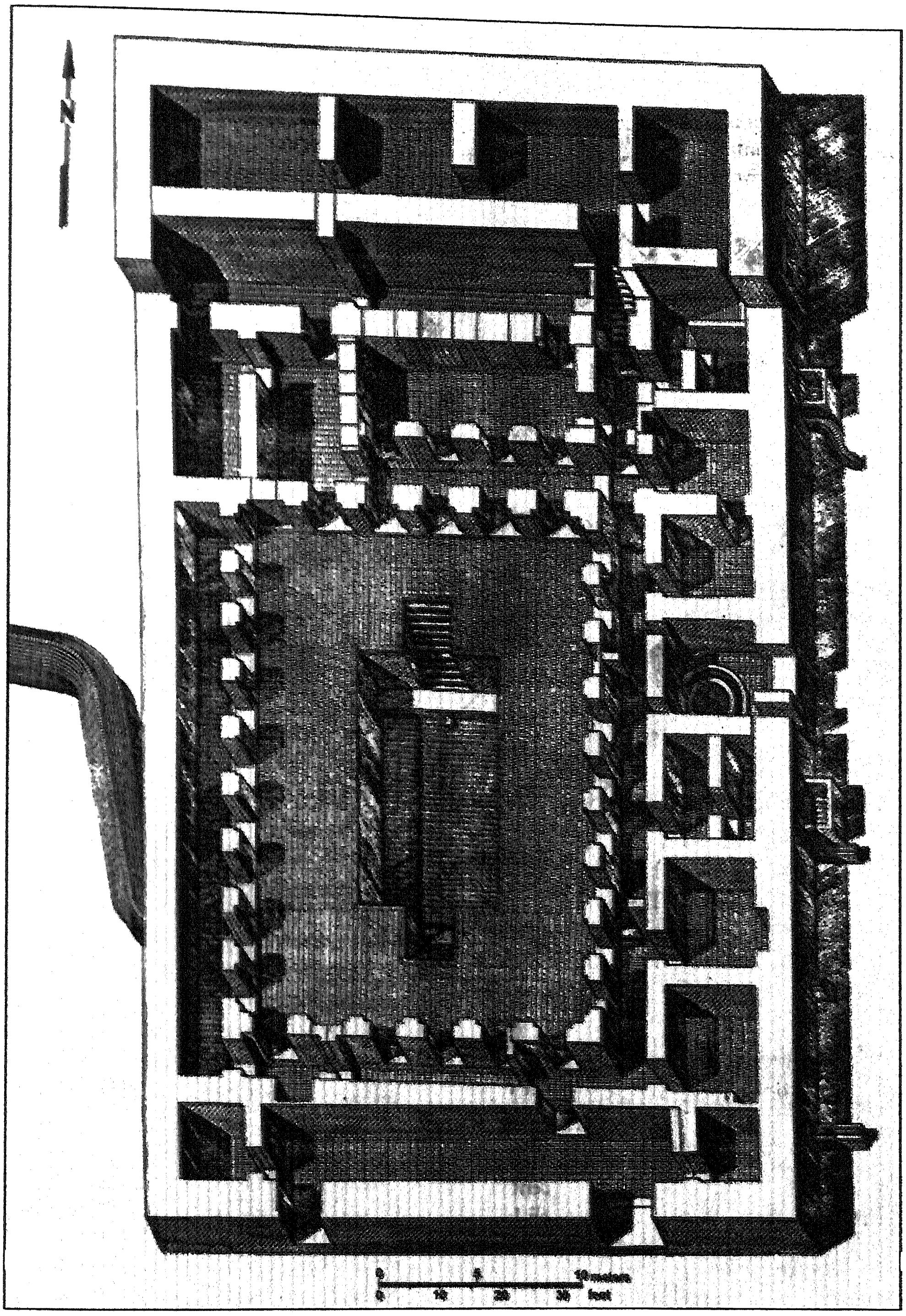

Fig. 5.9: view of Great Bath

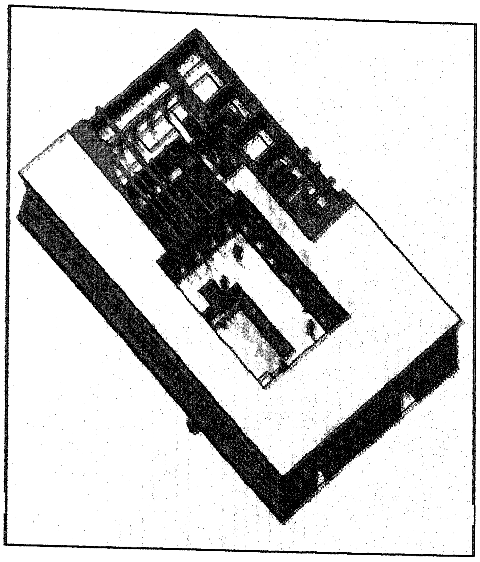

Fig. 5.10: Reconstruction of Great bath

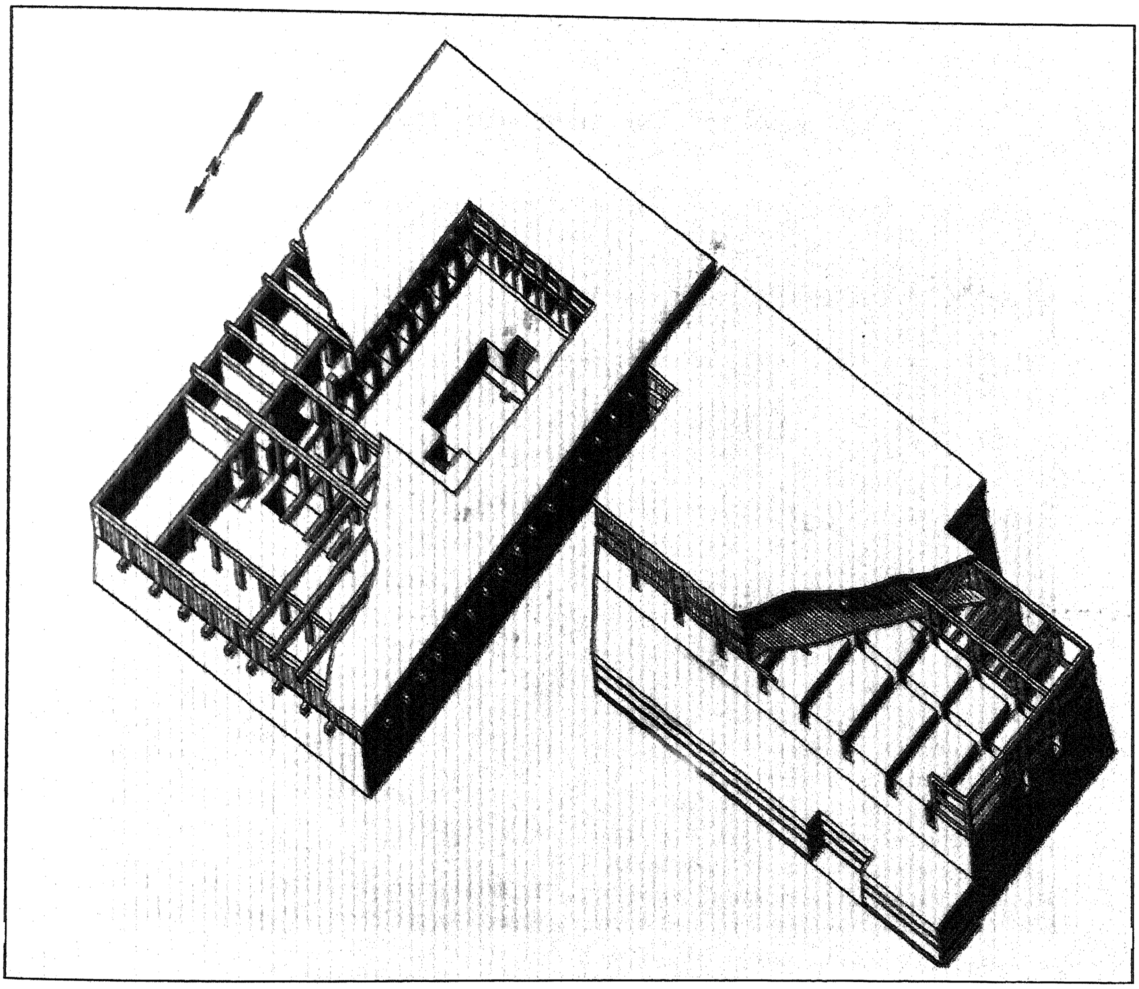

Fig. 5.11: Reconstruction of Great Bath and Granary

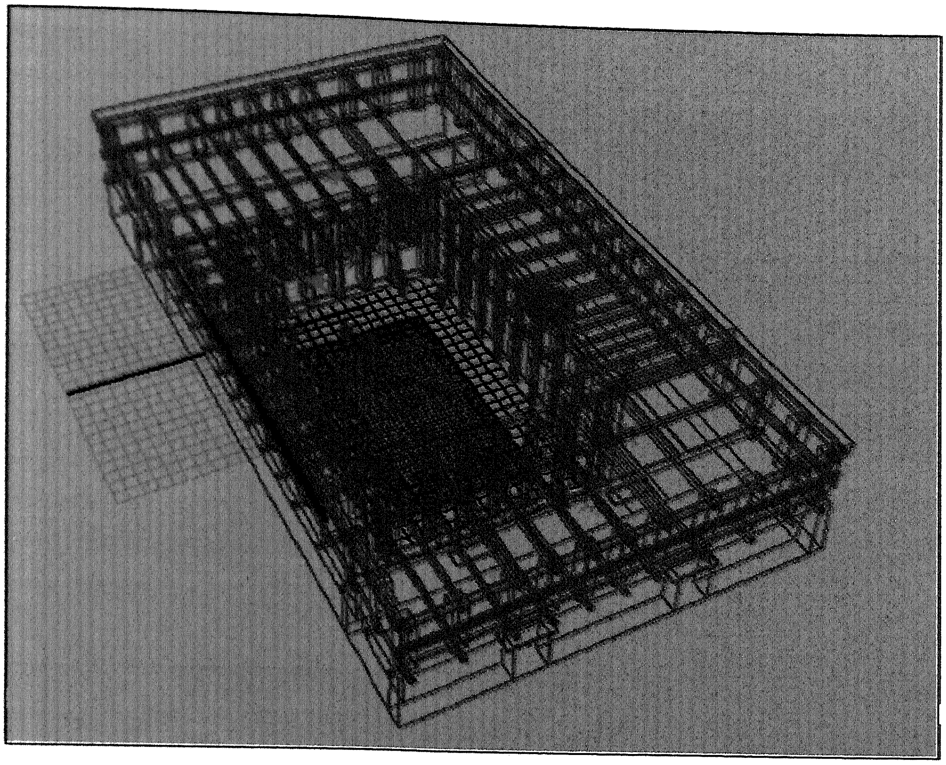

Fig. 5.12: Great Bath restoration – wire frame Model

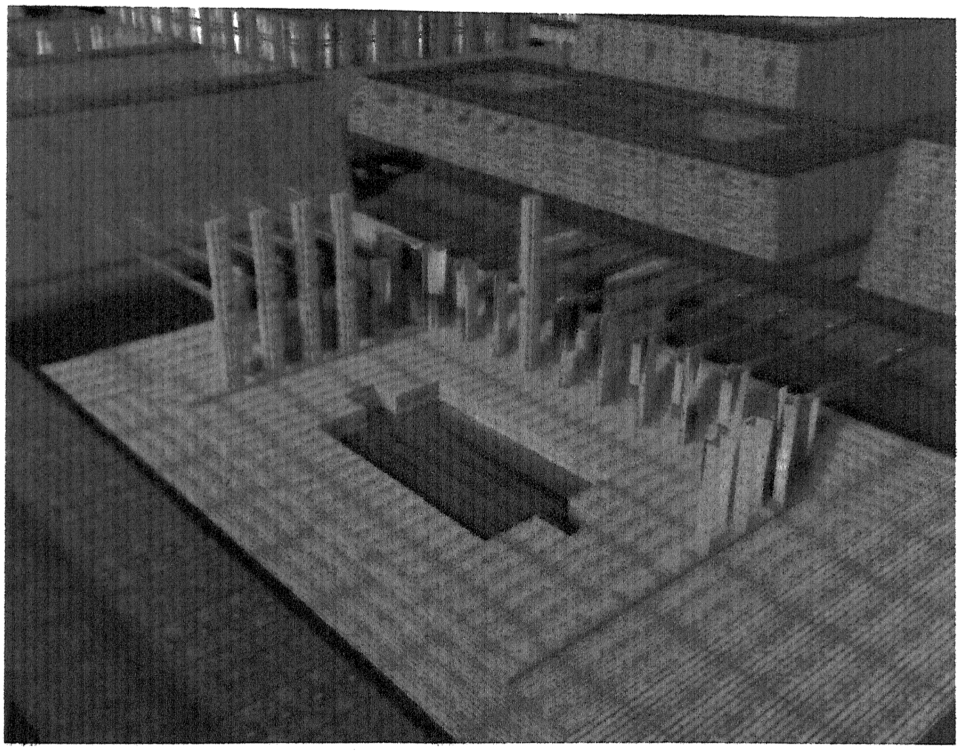

Fig. 5.13: Great Bath restoration – Phase1

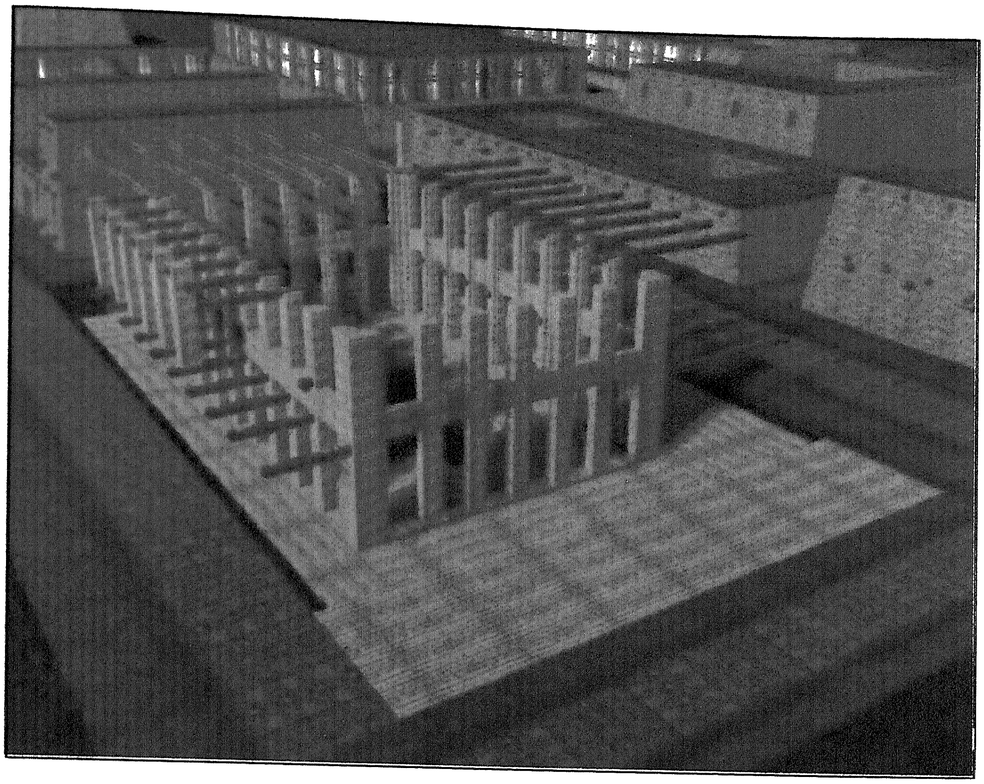

Fig. 5.14: Great Bath restoration –Phase2

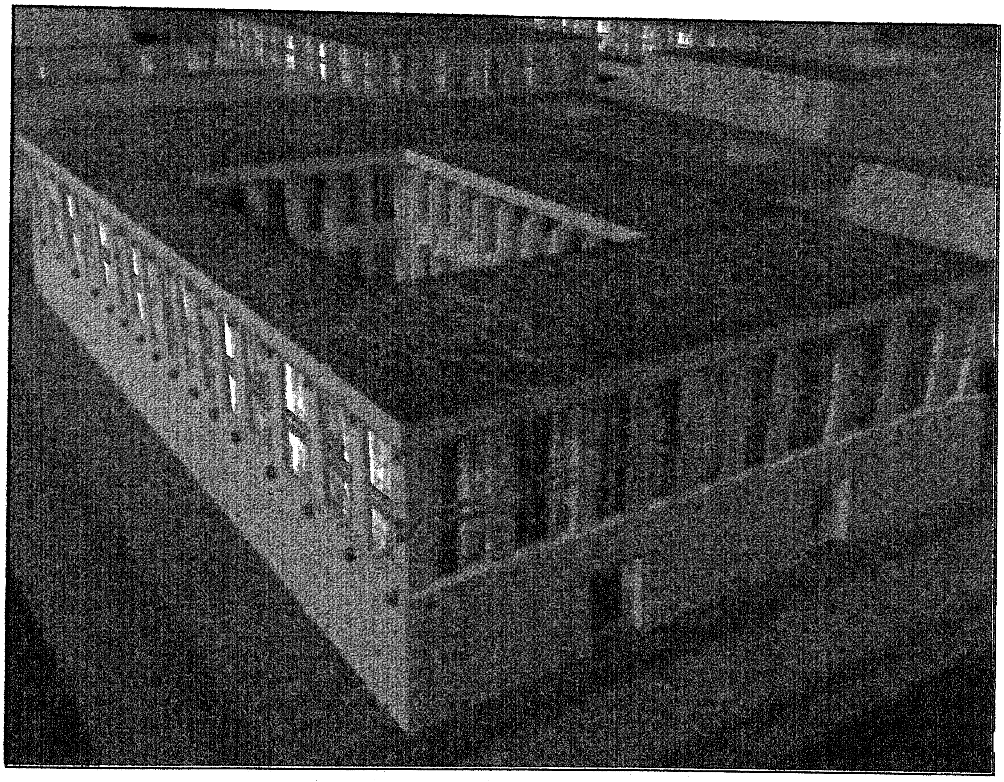

Fig. 5.15: Great Bath restoration – Phase3

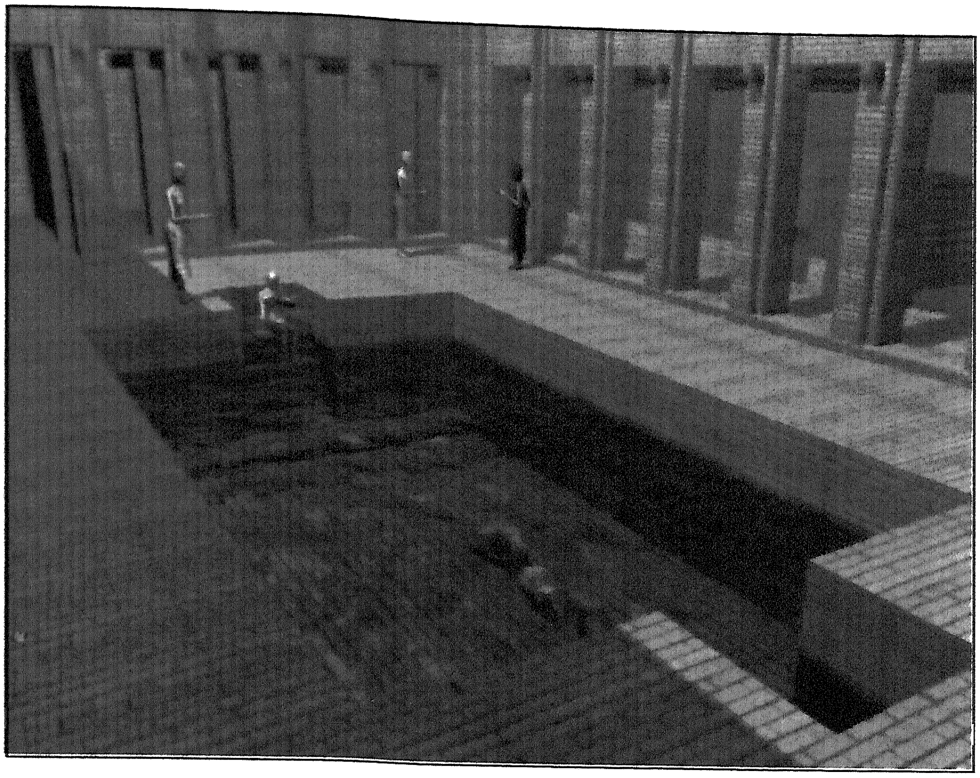

Fig. 5.16: Great Bath with water

Fig. 5.17: Priest at Great Bath

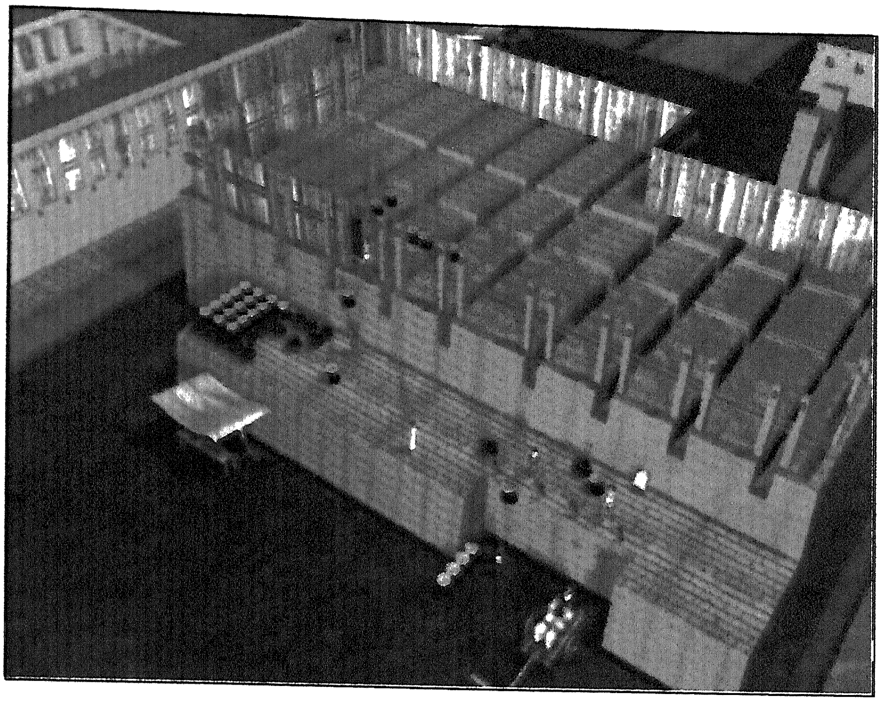

Fig. 5.20: Granary reconstruction

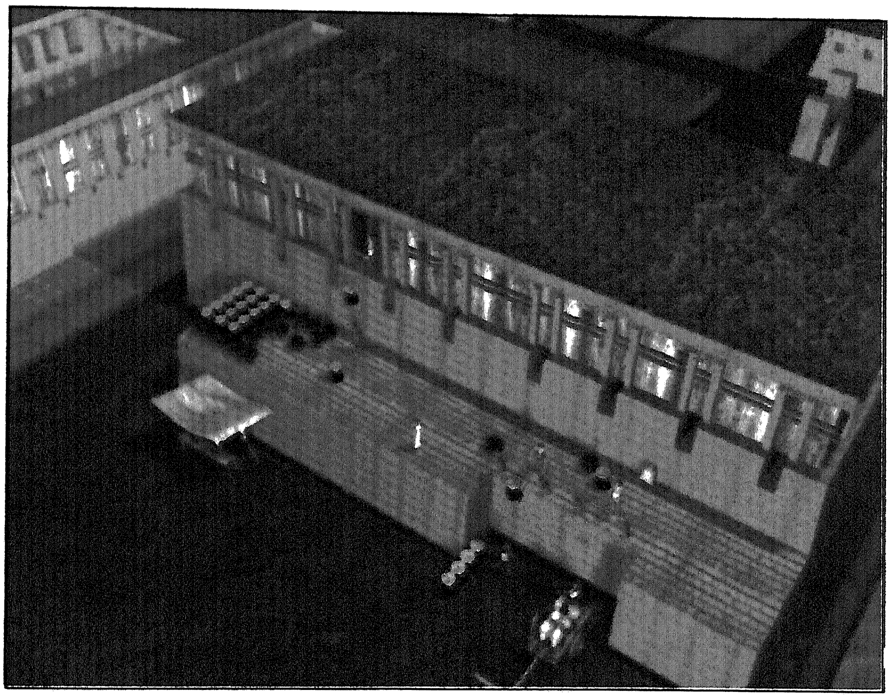

Fig. 5.21: Granary reconstructed

5.4 DIGITAL RESTORATION OF POTTERY

Fig. 5.22: Indus valley Pottery

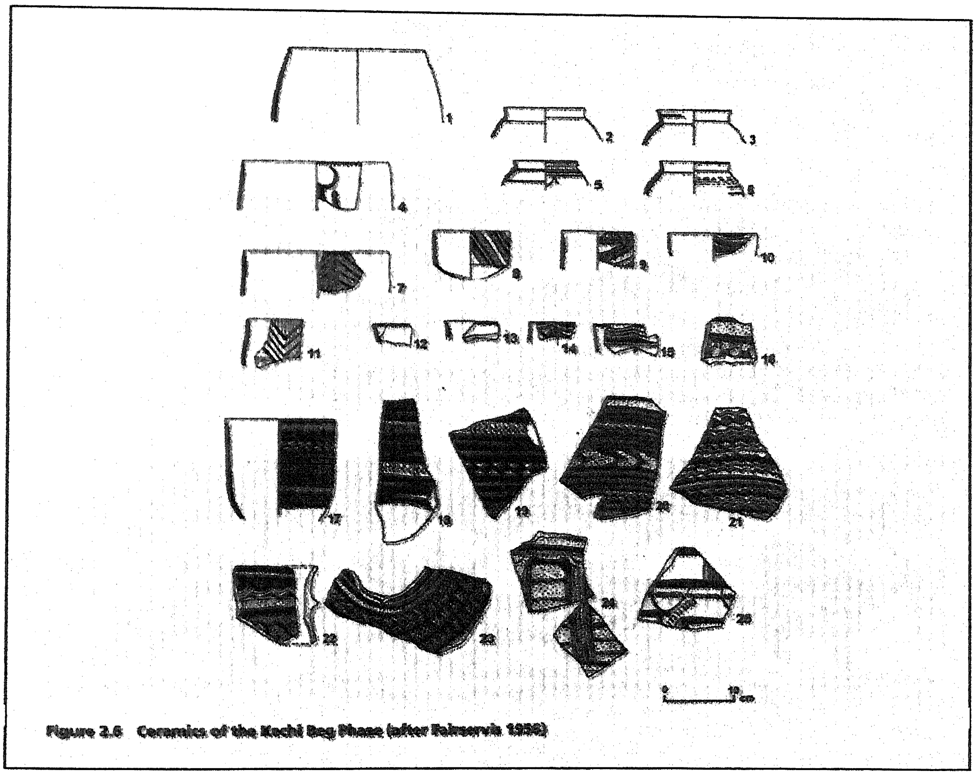

Fig. 5.23: Indus valley Pottery

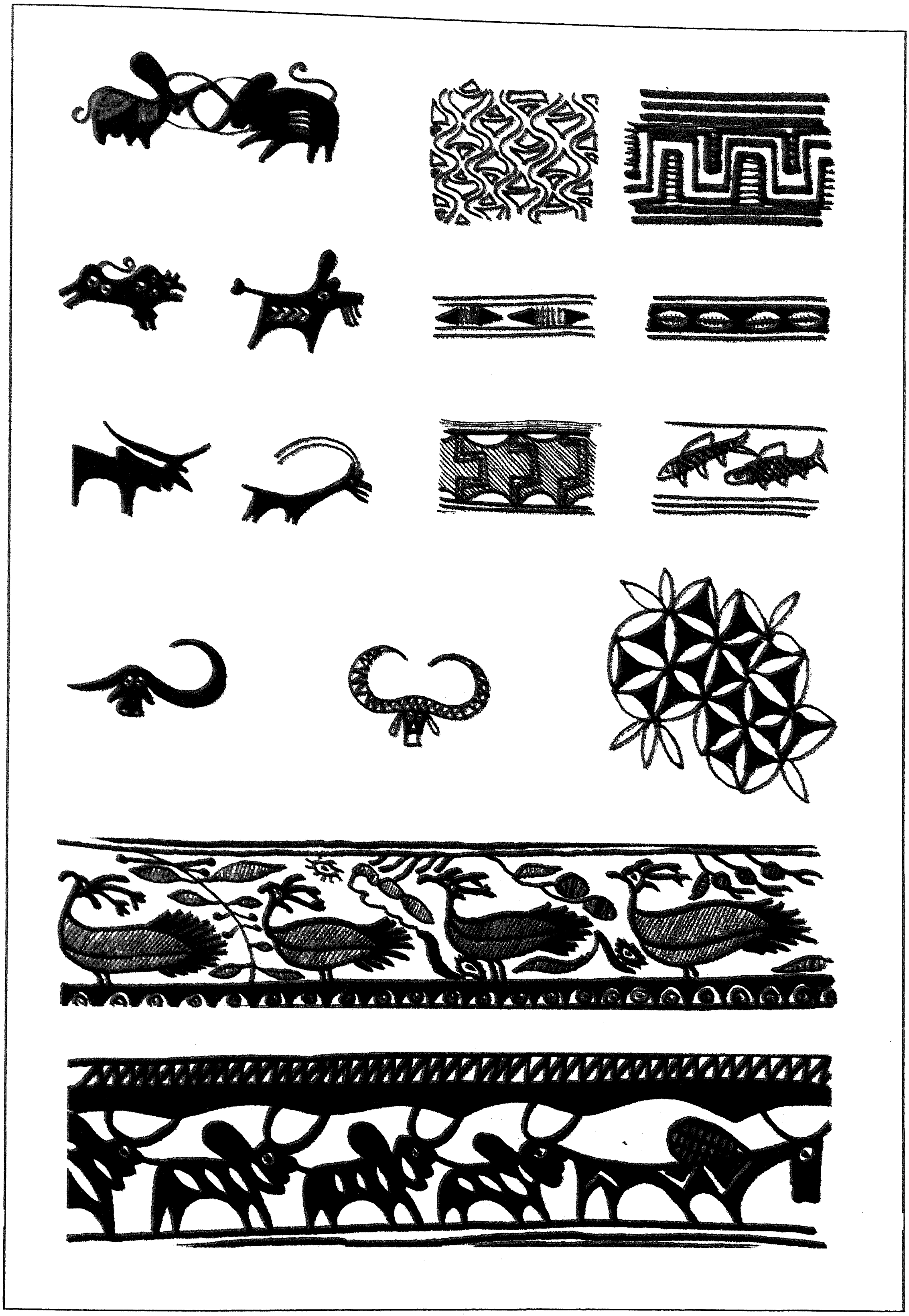

Fig. 5.24: Motifs Created from Indus valley pottery

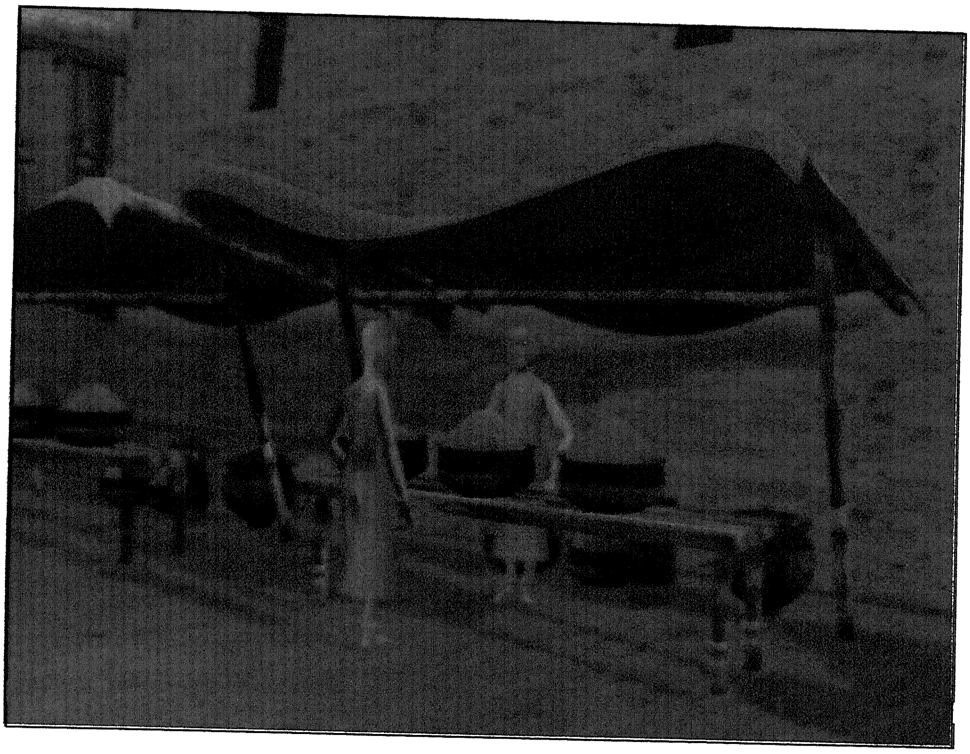

Fig. 5.25: Market Place

Fig. 5.26: Market Place - Pottery shop

Fig. 5.27: Market Place

5.5 DIGITAL RECREATION OF CART

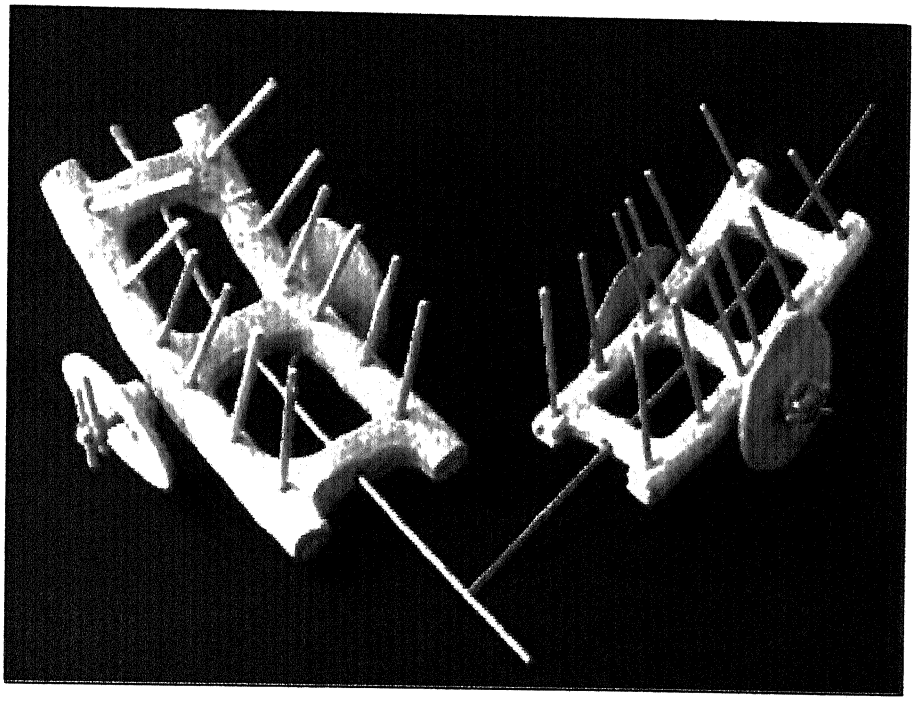

Fig. 5.28: Terracotta toy cart

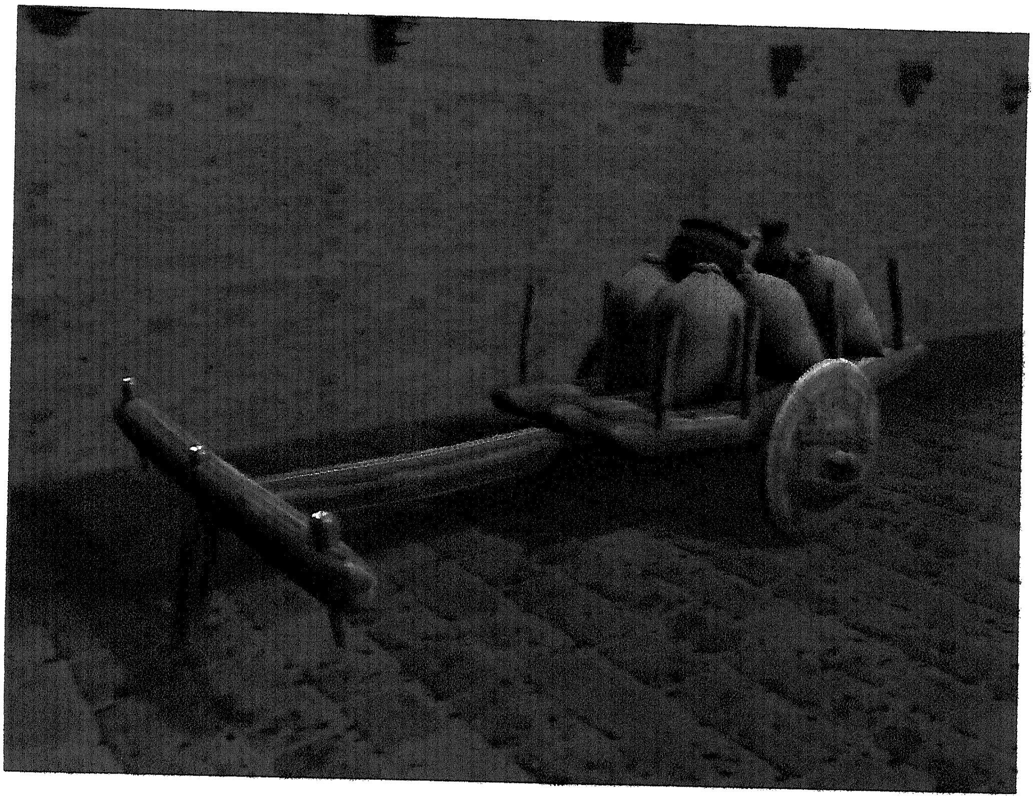

Fig. 5.29: Cart reconstructed

5.6 DIGITAL CHARACTERS CREATION

Fig. 5.30: Indications of possible ethnicity from terracotta figurines from mohenjo-daro and Harappa .

Fig. 5.31:
Indus women drapery

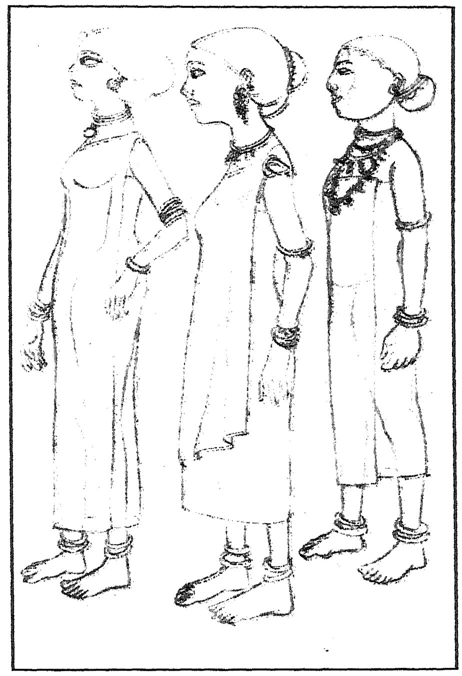

Fig. 5.32:
Female character sketches

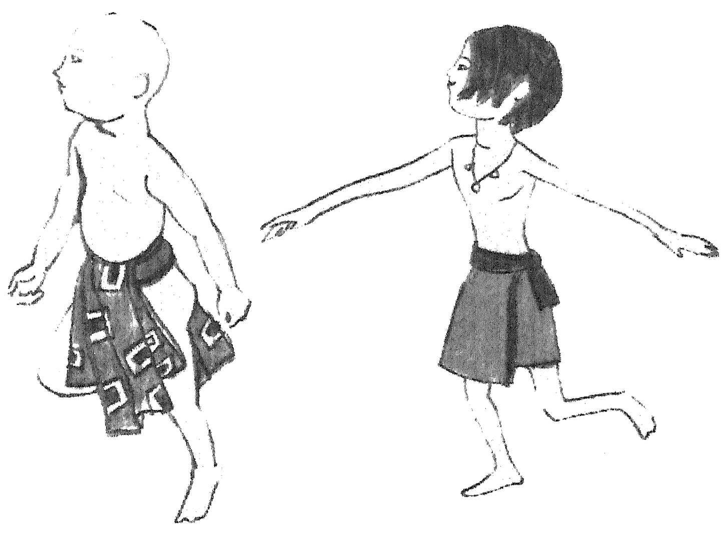

Fig. 5.33: Indus Children sketches

5.6.1 Priest King

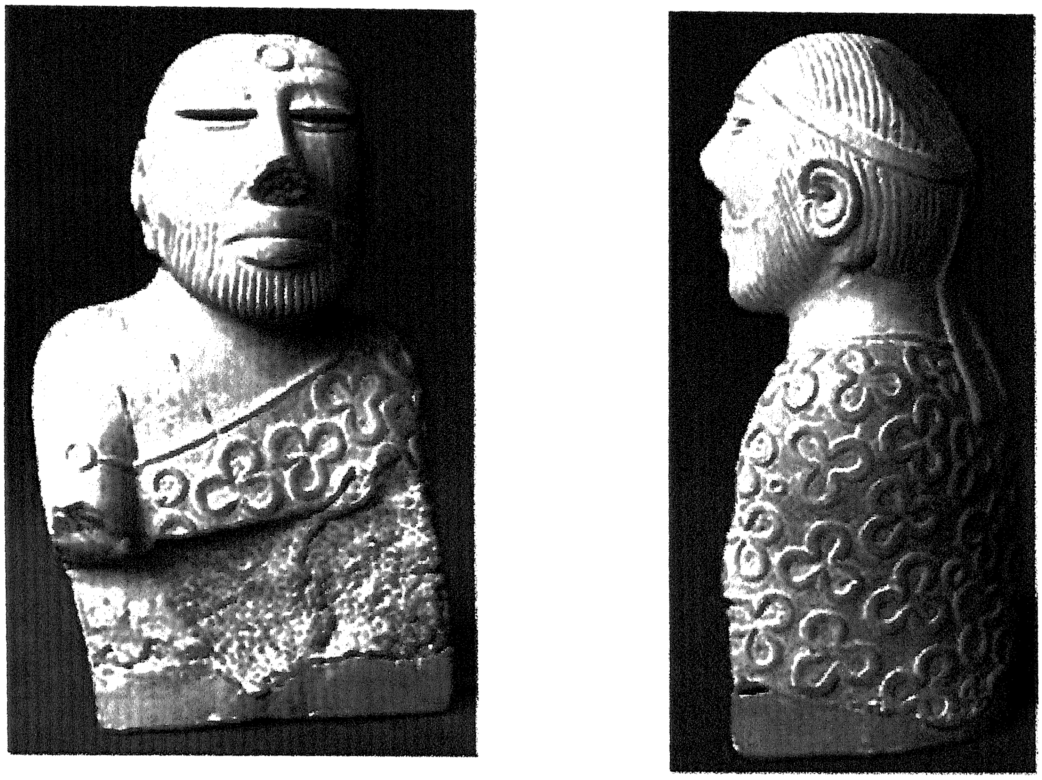

Fig. 5.34: Priest head from Mohenjo-daro

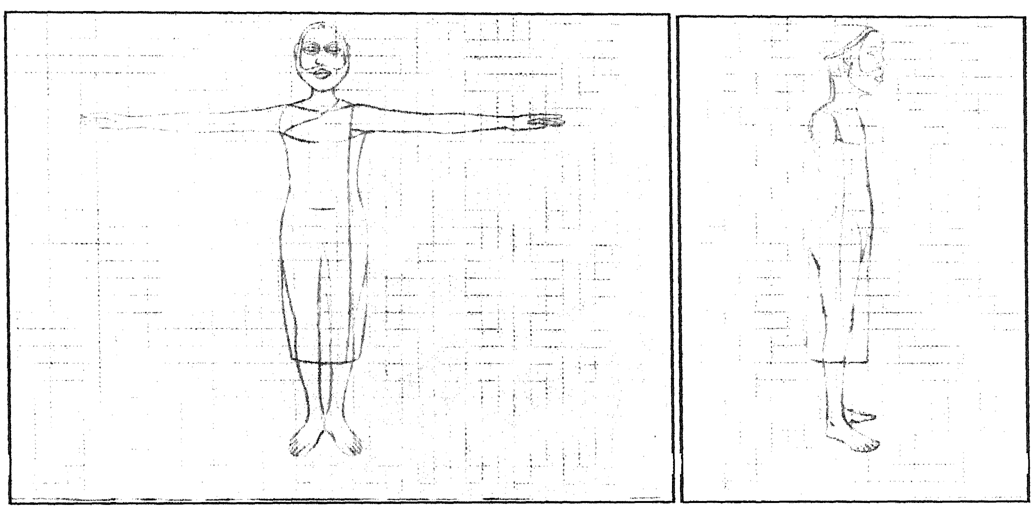

Fig. 5.35: Character sketches for modeling

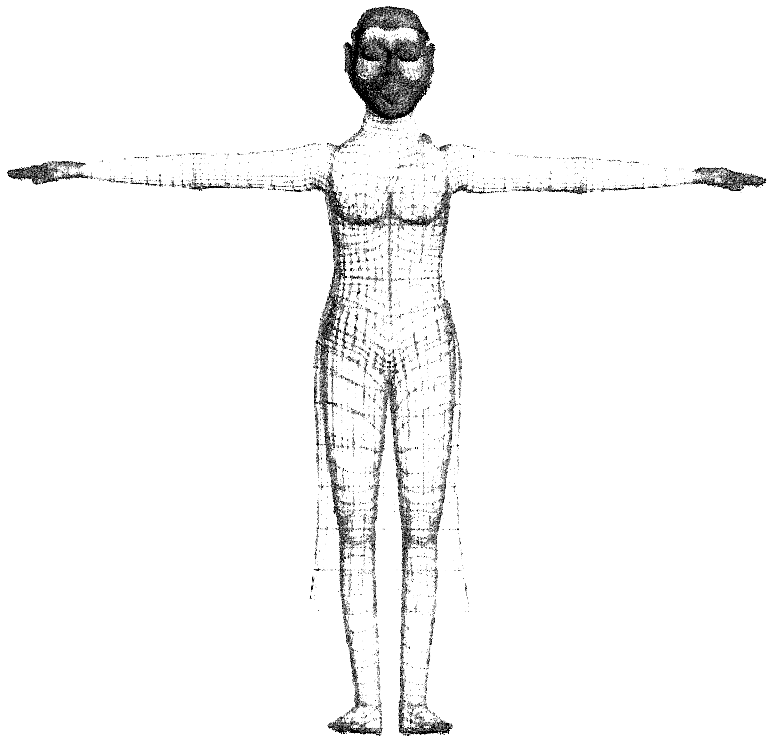

Fig. 5.36: 3D models of Priest King

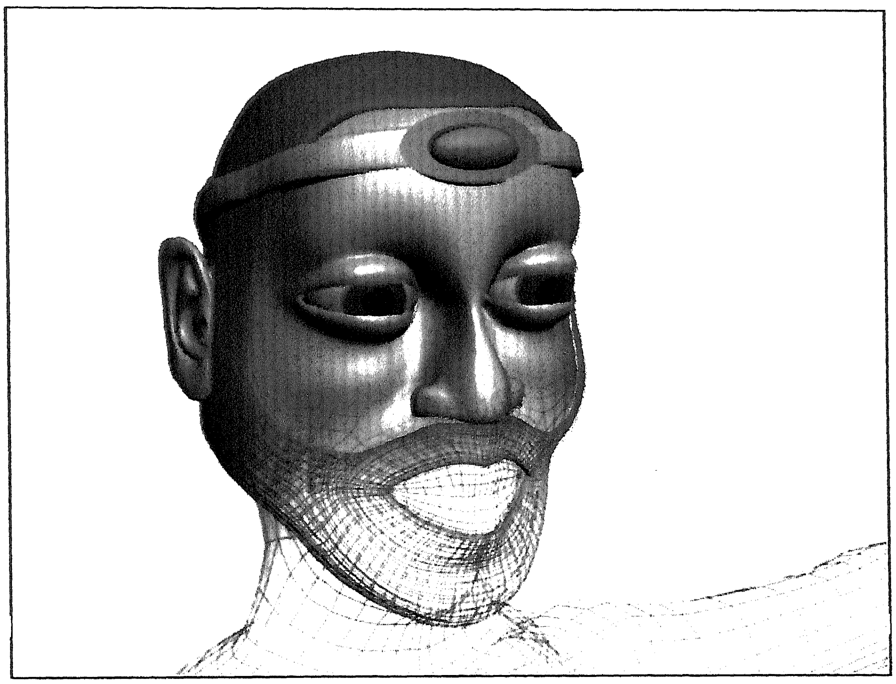

Fig. 5.37: Priest Head

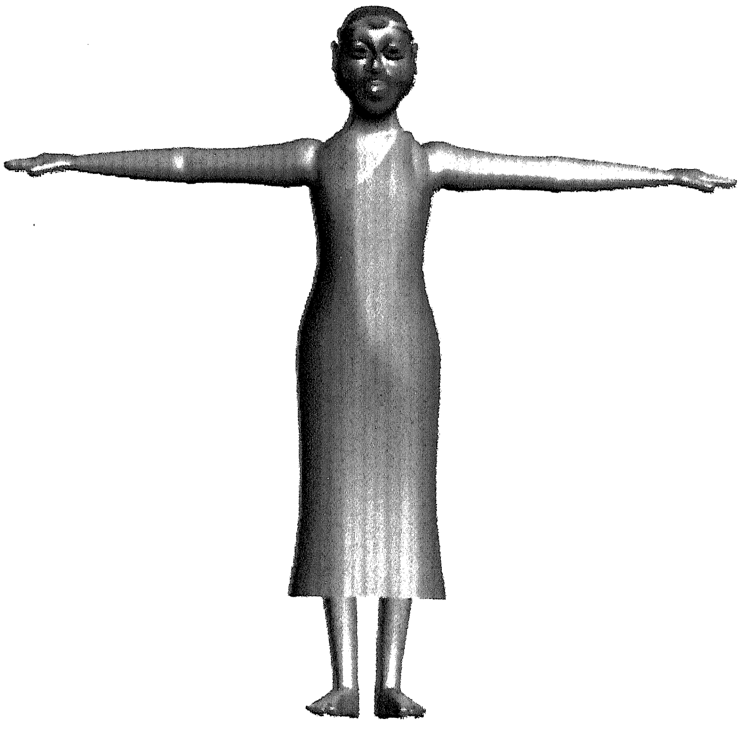

Fig. 5.38: Priest king 3D Model

5.6.2 Indus Man

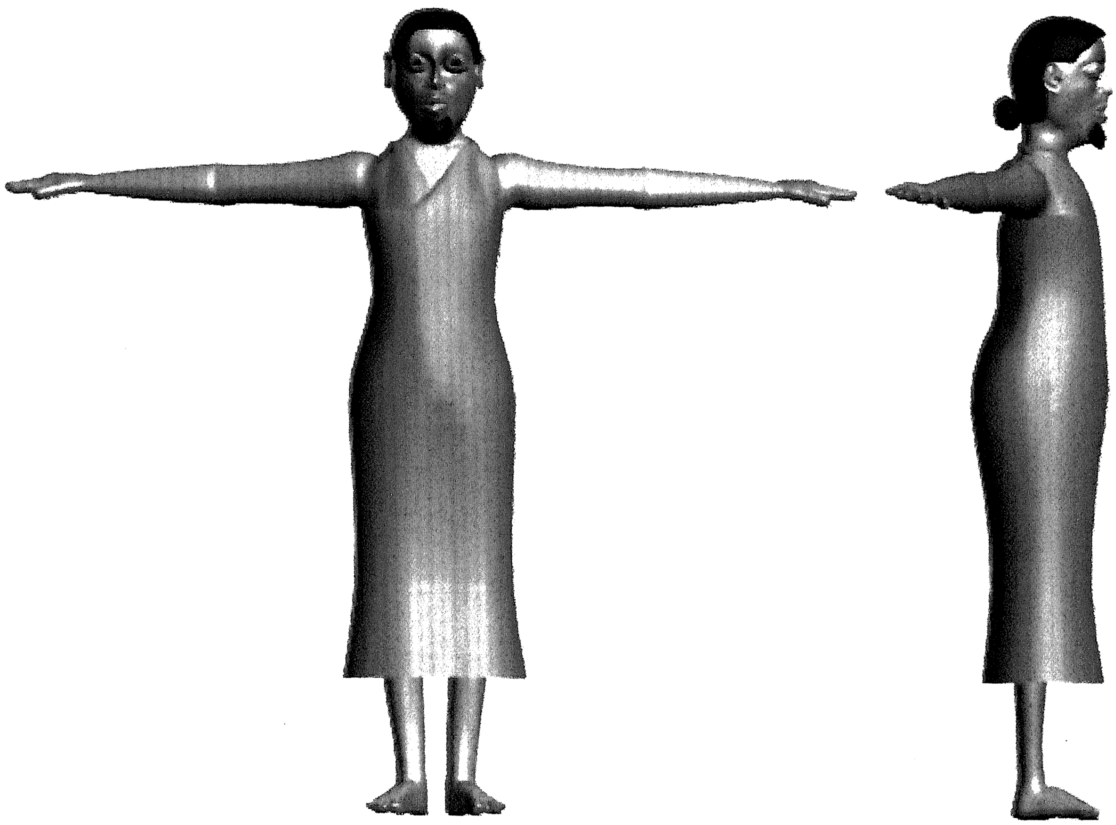

Fig. 5.39: Indus Man

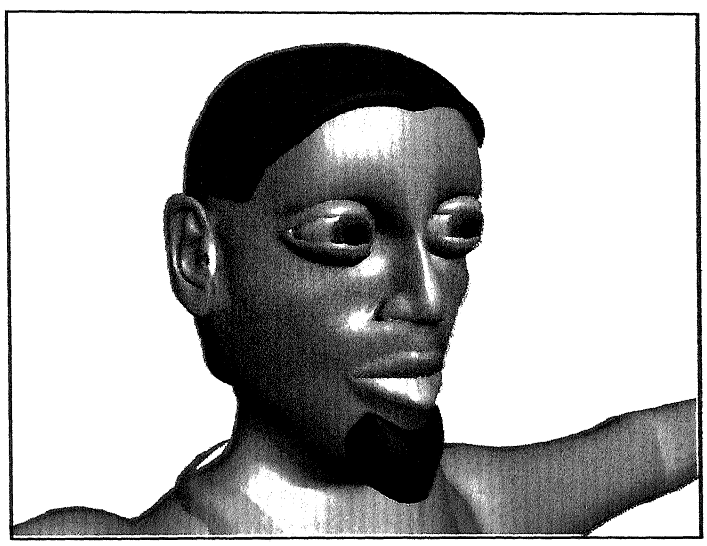

Fig. 5.40: Indus Man

5.6.3 Indus valley Kid-1

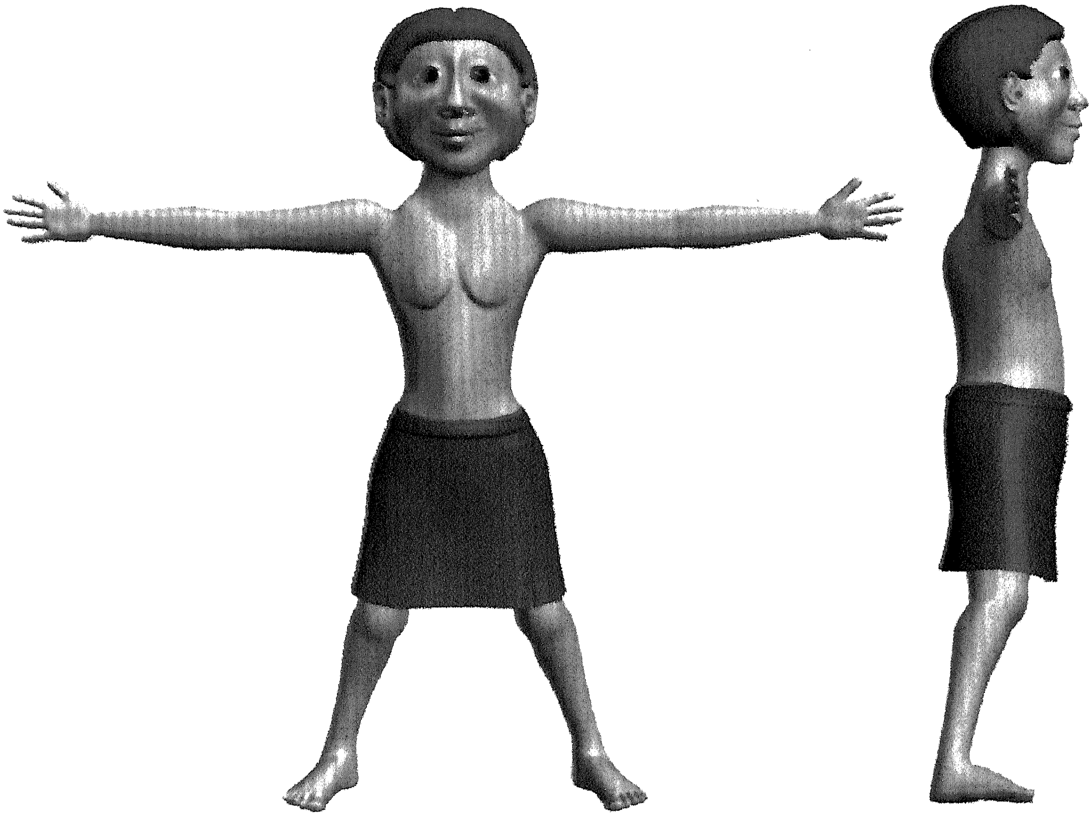

Fig. 5.41: Indus Valley Kid-1

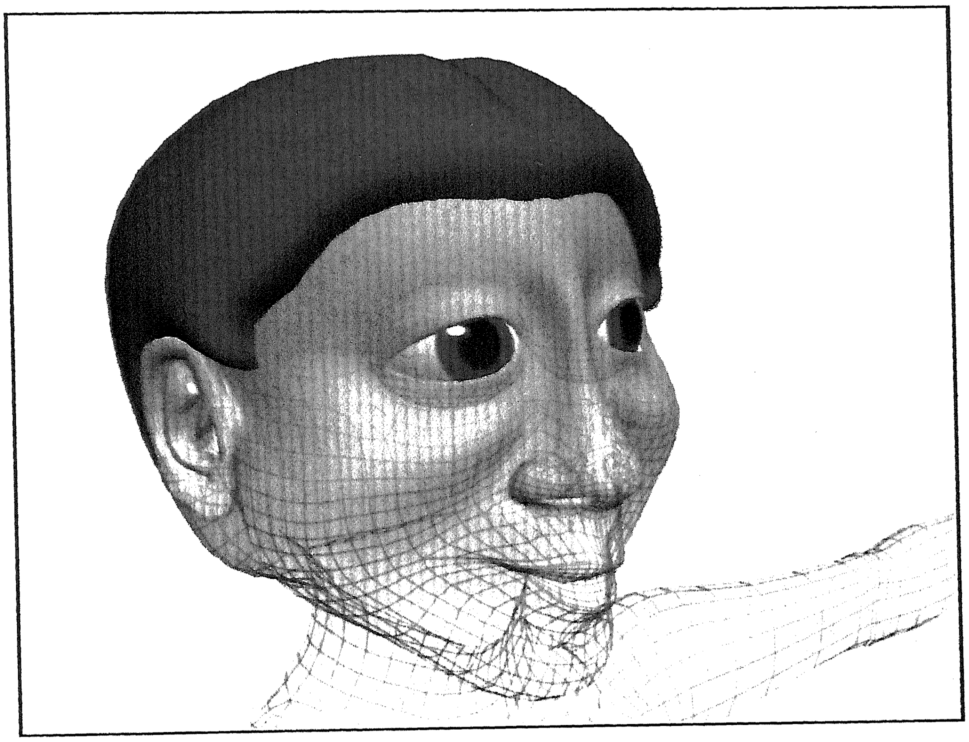

Fig. 5.42: Indus valley Kid-1

5.6.4 Indus valley Kid-2

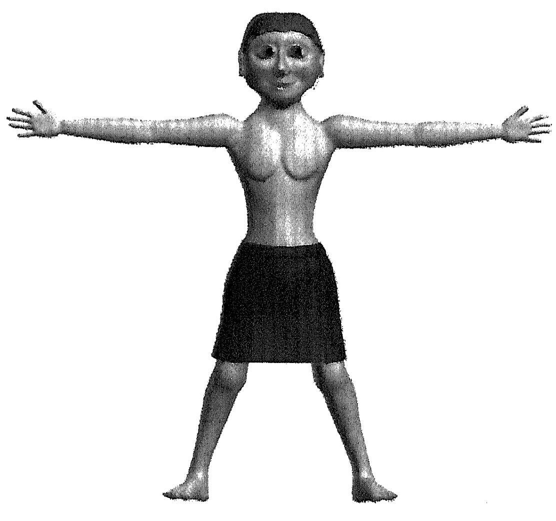

Fig. 5.43: Indus valley Kid-2

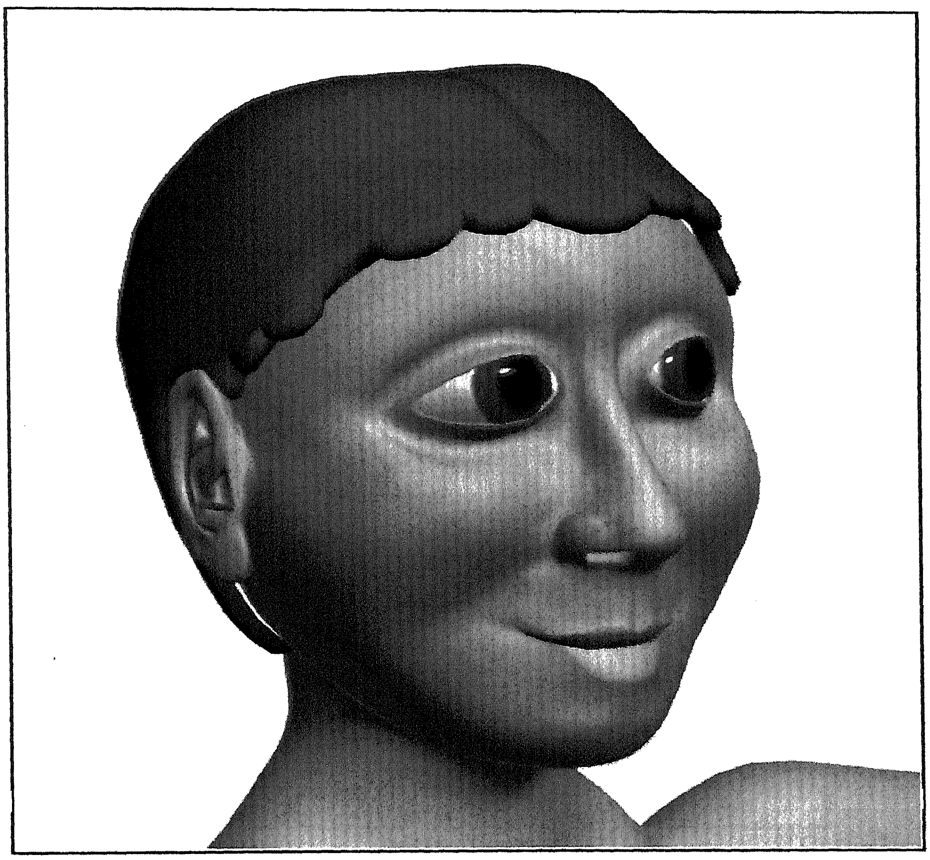

Fig. 5.44: Indus valley Kid-2

5.6.5 Indus valley Female-1

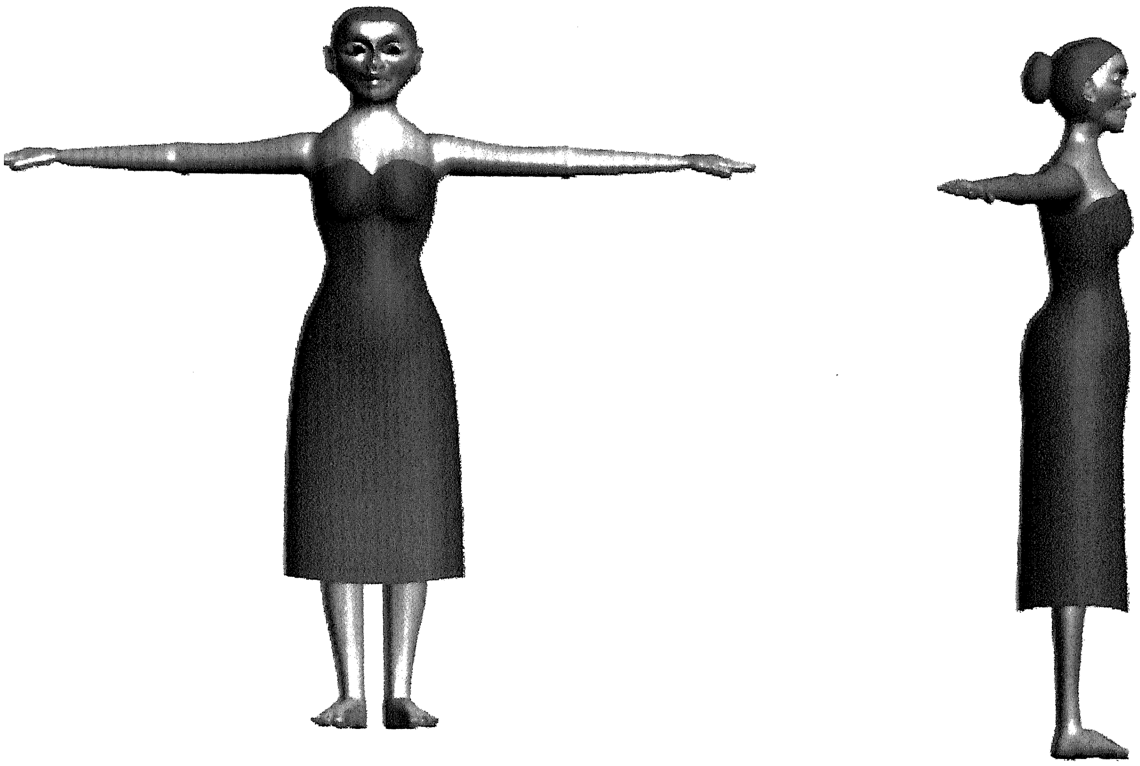

Fig. 5.45: Indus valley Female-1

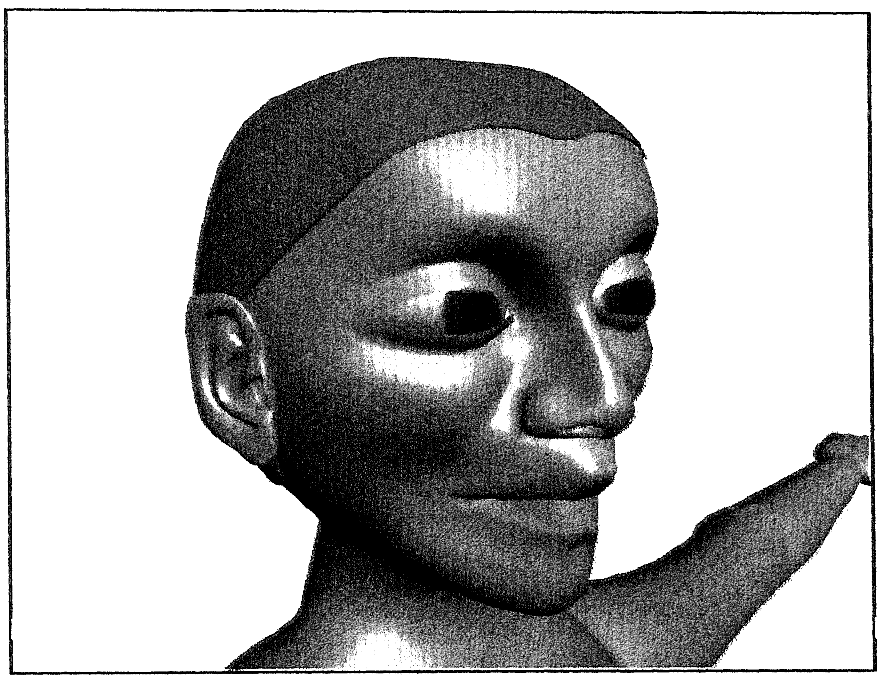

Fig. 5.46: Indus valley Female-1

5.6.5 Indus valley Female-2

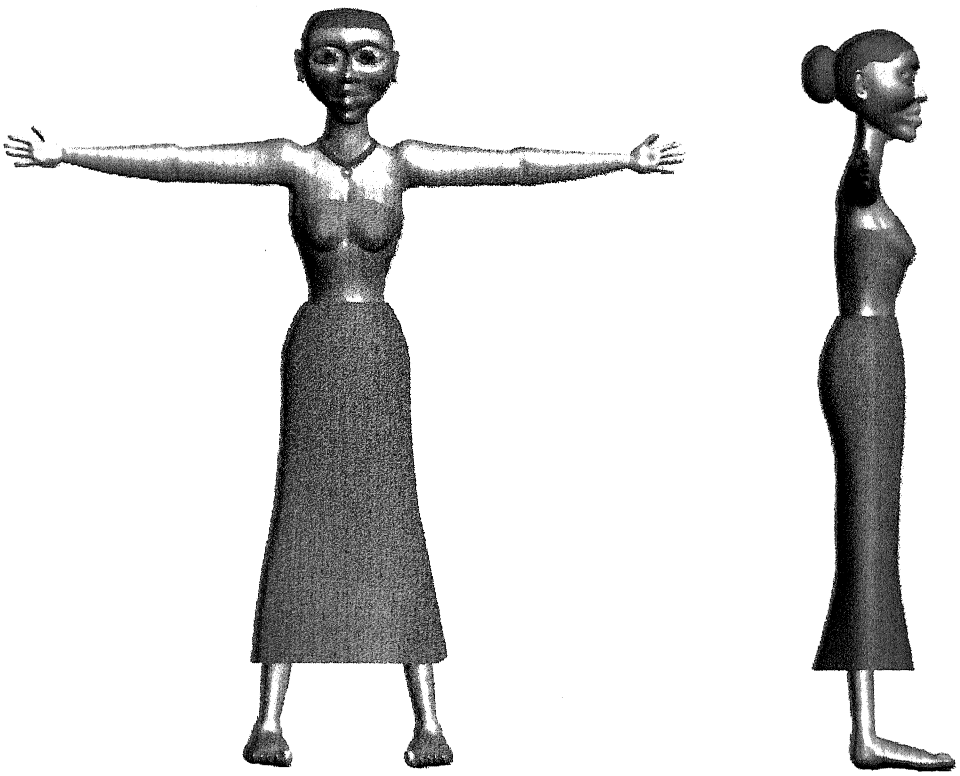

Fig. 5.47: Indus valley Female-2

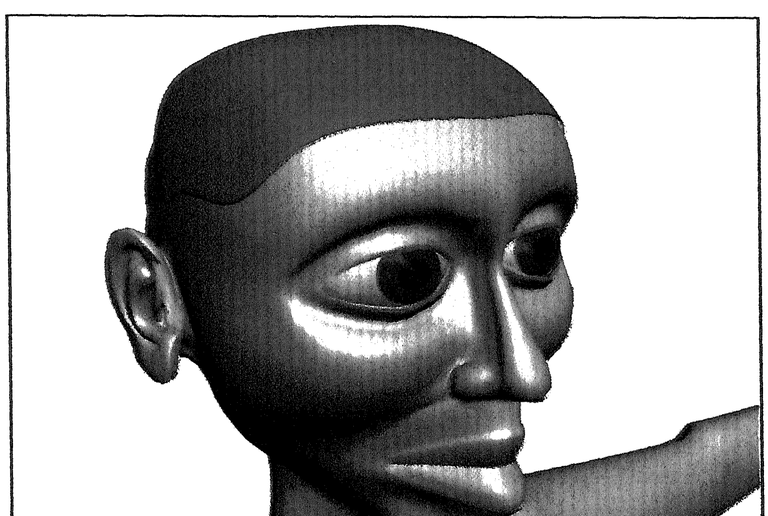

Fig. 5.48: Indus valley Female-2

CONCLUSION

INTERACTION IN LEARNING ENVIRONMENTS

Further development would be of creating a interactive game based on the multimedia content. The development of new interactive technologies inevitably has an impact on all aspects of teaching and learning. Children lives are increasingly devoted to video game playing, navigating the Internet. Thus we have found a new powerful incentive to use in children education.

Computers have advanced to the point where immersive, complex 3D environments are a possibility even for training in less expensive areas of application. For example in the past it was too expensive to develop a reasonable training simulator for regular infantry. Now this is possible with the advent of technology originally developed for the civilian gaming industry. An example of this is a game called Operation Flashpoint, developed in 2001 by Bohemia Interactive Studios, a Czech game studio. Shortly after the game was released, the United States Marine Corps expressed an interest in using a modified version for infantry training. After having played it, it isn't hard to see why it might be good for this purpose, the game offers unparalleled tactical freedom of choice, combined with a myriad of realistic small details, delivering not only an awesome gaming experience, but also an eye-opening experience why war is definitely best kept in a computer game if at all humanly possible.

We see this and many other examples as a clear indicator of a convergence of the entertainment industry and the training software industry. Before games were games, and educational software was educational software. With the advent of more affordable 3D technology, makers of educational software now have more options than ever before. Examples of this more affordable technology are in names like 3Dfx, OpenGL, and other similar standards, which finally put cutting edge technology into the hands of educators who seek to make material.

Another form of convergence is that the gaming industry has started to use more realistic and accurate, and therefore at the same time more **educational** material in making games. It's much easier to learn something, even by accident, when the game is more deep, immersive and realistic in whatever field or are it chooses to be situated in.

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